4.1 Overview of data sources for the Pacific halibut stock assessment and related analyses

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Introduction

This document provides a summary of the data sources available for the Pacific halibut stock assessment, apportionment, harvest policy, Management Strategy Evaluation (MSE), and related analyses. It began as background for the 2013 stock assessment (Stewart 2014), and serves as an annually updated source for direct evaluation of the data and processing methods employed. For each data source, a brief narrative is provided which includes the source, steps taken to filter and analyze the data, and the key quantities available for subsequent analysis. Data sources are described within the categories of: fishery-independent, fishery-dependent, and auxiliary sources of information. The level of detail is adjusted annually to allow for additional description of new sources or changes in analysis methods; final detail presented in previous versions is not repeated annually if there has been no change to the methods or results.

Also provided in this document is a brief synopsis of important changes made in the current year, as well as a list of data sources or analyses that are currently not directly used, but are potentially available for future analysis. The latter includes some comment on avenues for additional data collection and/or analysis.

Fishery-independent data

Fishery-independent data are generated each year by the IPHC's setline survey, covering most of the range of Pacific halibut habitat from the northern Bering Sea and Aleutian Islands to California, and depths of 20-275 fathoms (Soderlund et al. 2012, Henry et al. 2015; Fig. 1). The setline survey generates catch rate information, as well as biological samples from individual fish sampled randomly from the catch including: sex, length, age, maturity, the presence of prior hooking injury, and recently a small subsample of individual fish weights. These data are reprocessed each year for use in the stock assessment as new observations become available (Fig. 2). In 2016, survey data were augmented with additional stations along the 4D shelf-slope break near the U.S. and Russian Exclusive Economic Zone (EEZ) boundary (Webster and Henry 2017). This expansion represents the third in a six-year planned effort to sample all Pacific halibut habitat logistically possible within the 10-400 fathom (fa; 18-732 m) depth range. Importantly, for this year, all survey data reported here are the result of the newly developed space-time model fully described in Webster (2017).

In addition to its use in supplementing the IPHC setline survey data, the NMFS trawl surveys in Alaska (particularly the Bering Sea) provide valuable information on the size and abundance of Pacific halibut in the Eastern Bering Sea (Sadorus and Lauth 2016). Beginning in 2015, these data have been used to estimate size-at-age for young Pacific halibut not frequently encountered in the IPHC survey, as well as trends in abundance and age structure.

Survey WPUE (Weight-Per-Unit-Effort)

The catch-rate information from the setline survey serves as the primary source of trend information (along with commercial catch-rates) for the stock assessment.

For 2016, the survey trends reported here reflect the output of the space-time model documented in Webster (2017). That analysis reconciles previously developed corrections for missing regions, hook-competition, timing of the survey relative to the fishery catch, and extracts better information than simpler methods due to the explicit use of spatial and temporal correlation in catches among stations. The results of this modelling, although qualitatively very similar to previous results, differ in that they are generally smoother (less inter-annual variability), and have more statistically meaningful variance estimates.

The coastwide legal-size (above the 32 inch (81.3 cm) minimum size limit, or O32) survey WPUE index is estimated to have increased by 6% from 2015 to 2016 (Table 1, Figs. 3-4). This follows modest increases in the two previous years, and results in a relatively flat trend in WPUE since 2010. All of Area 2 now shows consistently increasing trends over the last 8-10 years, with areas 3A-4B relatively flat over the most recent 3-5 years. Area 4CDE is estimated to have been increasing since 2011, but to have remained flat (-1%) between 2015 and 2016.

The stock assessment models fit directly to the observed Numbers-Per-Unit-Effort (NPUE) from the setline survey, in order to avoid converting observed lengths to weights based on the length-weight relationship, and to provide a delineation between changes in the number of fish and changes in the size of those fish (included in the models via the mean weight-at-age; see below). The revised survey modelling estimates (WPUE and NPUE) differ from previous estimates in several important ways. First, trends have been more clearly increasing in Area 2 over the last 5-10 years; and increasing over a longer period in areas 2B and 2C than in Area 2A (Figs. 5-6). Second, declines are estimated to have been somewhat more constant in Areas 3A and 3B. Third, the overall coastwide trend is somewhat more muted, with only a decline of approximately 15% since the late 1990s and three years of increase at the end of the series. The latter result in particular indicates that the declines in WPUE have been even more strongly influenced by weight-at-age than previously believed. Very similar trends have been observed for NPUE when compared to the WPUE; however both the O32 and total NPUE show more modest historical declines. When aggregated into geographic regions, these patterns in NPUE become more easily visualized (Figs. 7-8).

For this year's analysis, estimates based on the space-time model were unavailable for years prior to 1998. Although it is anticipated that the approach can be extended to include these years in the near-future, previously summarized values were used for those early years with more sparse geographic coverage. These data represent only Areas 2B, 2C, and 3A (the geographic 'core' of the stock) for the years 1982-1996, and only Areas 2B and 3A for the years 1977-1981. In 1984, among other changes to the station design and coverage, the setline survey (following the commercial fishery the year before) converted its standard gear to include circle hooks; this greatly increased catch rates from previous years.

Survey age distributions

Otoliths are collected randomly from Pacific halibut captured by the setline survey, with sampling rates adjusted by regulatory area to achieve a similar number of samples from each area in each year. All otoliths collected during survey activities are read each year by IPHC age-readers. Because the survey catch is sampled randomly at the same rate for all stations within a given regulatory area and year, the raw frequency of ages is an appropriate estimate of the aggregate for the area. Age distributions differ between male and female Pacific halibut and among regulatory areas, with older fish comprised primarily of males, and occurring in much greater numbers in the western and northern regulatory areas (Fig. 9). In 2016 a much larger proportion of males was observed at all ages than in recent years. Ten- and eleven-year-old Pacific halibut represented the largest proportion of survey catch in many areas in 2016, with age-9 females slightly more common than age-11s in Area 2A.

In order to weight these area-specific distributions, an estimate of the number of Pacific halibut in each area is required. This is obtained via the NPUE, as the relative numbers in each regulatory area provide a weighting for combining the age-frequency distributions into a coastwide aggregate (Fig. 10). From the late 1990s through the mid-2000s, the strength of the 1987 year class is particularly evident in these data. The age frequencies over the last five years are relatively constant, dominated by ages 8-16, with some indication of stronger 11-12 year old fish, consistent with observations in NMFS trawl surveys (see below) of strong 2005-2006 cohorts.

Ages have been aggregated at age-25 for all observations using the break-and-bake ageing method. This method was adopted for all Pacific halibut age-reading by the IPHC (see section on ageing bias and imprecision below) in 2002. 20 (all ages-20 and older combined) for all data (survey and fishery) collected prior to 2002 when Most ages read prior to 2002 used surface ageing methods, except for 1998, where a randomly selected subsample of otoliths were re-aged (during 2013) and ages can now be more reliably interpreted out to age-25 (see Stewart 2014, and Forsberg and Stewart 2015 for more information on these samples).

As for the catch-rate data, there are some sparse age data available prior to 1997. These age data represent only Areas 2B, 2C, and 3A for the years 1982-96, and only Areas 2B and 3A for the years 1980-81. These earlier data do not reveal any particularly strong cohorts, nor do the cohort strengths appear appreciably different for male and female Pacific halibut. The age data were also aggregated into geographic regions, revealing important differences in age structure (Figs. 11-12). Specifically, there have been very few Pacific halibut greater than age 20 of either sex observed in Area 2, but fish of those ages, and particularly males, become more common in the western and northern portions of the stock. Area 4B shows the highest proportion of age 25+ Pacific halibut for both males and females (Fig. 12).

Sublegal survey age distributions

Beginning in 2015, the age-distribution of sublegal Pacific halibut captured by the setline survey was used as a means to approximate the Pacific halibut comprising commercial wastage, or Pacific halibut captured as part of the commercial fishery, discarded, and a portion of which are assumed to subsequently die (Stewart and Martell 2016). These data show a remarkably protracted age-distribution, particularly for males in Area 3A (Figs. 13-14). The age-distribution for the two sexes also differed importantly, with sublegal females present in appreciable numbers from roughly age 7 to 11, and sublegal males from 7 to well beyond age 15 in some years. The protracted age structure of fish below the 32” minimum size-limit illustrates the effects of variability in size-at-age: some fish from each cohort reaching the minimum size limit by age-6, and others (particularly males) many years later.

Survey weight-at-age

The survey collects individual length observations on all Pacific halibut captured, which are then converted to estimated weights via the length-weight relationship (see section below). Age estimates are also available for a random subsample of these lengths.

Ages consist of primarily surface ages prior to 2002, and exclusively break-and-bake ages from 2002 to the present. Prior analyses of weight-at-age attempted to correct for the potential bias of surface ages by converting the weights corresponding to surface ages to the 'true' weight at age given an estimated level of bias (and some assumption of the underlying age structure). Investigation of the data prior to 2002 revealed that many of the surface ages also had corresponding break-and-bake ages that were not being included in the analysis (see summary of ageing bias and precision below). Replacing all surface ages with break-and-bake ages (where available) in the weight-at-age calculations appears to adequately address the differences in the ageing methods for the recent data.

Because the sampling of ages is random within the survey catches for an area each year, the average weight-at-age by area, sex, and year can be calculated directly. Where there are very few individuals in the population of a particular age, the number of survey age samples is also small (the age samples are not length-stratified). This pattern, in combination with incomplete survey sampling for some areas and years, results in a small number of missing weights-at-age within area and year combinations. These are simply interpolated from adjacent years. Because the survey captures few fish younger than age 7 or older than age 25, all fish outside this range are aggregated to these 'minus' and 'plus' groups (but see NMFS trawl survey section below). Although there has been a very strong trend of declining weight-at-age in recent years, there are marked differences in the magnitude of this decline among regulatory areas (Figs. 15-22, plotted only from ages 7-18 here for clarity). There also appear to be some patterns associated with specific cohorts; e.g., females in Area 2C born in the late-1990s (Fig. 17, upper panel). There do not appear to be consistent or strong trends from 2010-16 in the area-specific data.

These different trends among areas require appropriate weighting of the areas to create a coastwide time-series that represents the entire stock. The estimates of numbers of fish generated from survey NPUE are used to weight the individual regulatory areas. At the coastwide level, the stronger declines observed in the areas for which the greatest number of Pacific halibut are estimated to be present are evident, especially for the years prior to 2010 (Fig. 23). A broader comparison of historical observations predicted from a mix of fishery and survey data (See Fishery weight at age section below) indicates that the declines in size-at-age for female Pacific halibut were even more pronounced from the mid-1970s to the mid-1990s than in the recent period covered by the setline survey and differ by region, although current size-at-age is estimated to be at or near historical lows for all areas and coastwide (Fig. 24).

Spawning output-at-age

Survey data are also used to define the population-level weight-at-age and spawning biomass. Unlike the survey index calculation, where interannual sampling variability is logically included, the true population level quantities should be smoother than the raw observations. Applying a smoother across years within each age produces results more consistent with those expected for population level values; these summaries most clearly show the population-level decline in weight-at-age observed for both male and female Pacific halibut over the recent time-series available from the survey (Fig. 25). Survey observations of weight-at-age might include some bias relative to the population if size-based selectivity is operating on the distribution of lengths within each age. However, the matrix of population-level weight-at-age is most important in the assessment for those ages that are mature, for Pacific halibut mainly ages 11 and higher (see Maturity section below) which are less likely to experience significant bias.

NMFS trawl surveys in Alaska

Historical Pacific halibut assessments have used various extrapolation and smoothing methods to assign weight-at-age to fish that are younger than those observed in the IPHC's setline survey, which provides the most detailed source of sex-length-age information. These calculations are not critically important to the treatment of commercial fishery or survey information, as few very young fish are observed in those data sets; however, accurate depiction of the removals from other sources, such as recreational fisheries and bycatch in non-target fisheries requires representative weight-at-age for all fish captured, particularly ages 2-6.

Otoliths are collected by IPHC samplers on board NMFS trawl surveys in Alaska each year (Sadorus et al. 2017a, Sadorus et al. 2017b, Sadorus et al. 2016). The average weight-at-age by year and sex was summarized from the NMFS trawl surveys; age and length data were available for all years since 1998, although mean values were somewhat variable for ages greater than 10 due to limited sample sizes (Fig. 26). To reduce the effect of sampling variability (there is no easy way to account for observation error in the treatment of weight-at-age), raw values were smoothed across years within age (Fig. 27). These trawl survey weights-at-age were used to augment the weight-at-age inputs calculated from ages 7+ in the setline survey and commercial fishery. For the plus group (25+), the average age is calculated; this average age is then used to extrapolate the weight-at-age for ages 25-30. This is necessary because the average weight-at-age for all 25+ Pacific halibut combined should not be attributed to exactly age 25: the average age must be >25 unless all fish are exactly 25.

The ages observed on the NMFS trawl surveys provide year-specific information with which to estimate age distributions from that survey as well as other sources that report only length frequency information, but encounter Pacific halibut of similar ages, such as bycatch. However, there are no age data available from the NMFS trawl surveys before 1998, so a global (all-years) relationship (Fig. 28) must be used to interpret lengths collected in earlier years and other sources of length data (see age distribution of bycatch removals below). When this key is applied to the earlier years of the NMFS Bering Sea Trawl survey, several strong cohorts emerge (Fig. 29). The 1987 year class is prominent in the age distributions observed by this survey through the late 1990s. Strong 2004 and 2005 Bering Sea cohorts can also be observed graduating through the age distribution. These year classes are consistent with the catch rates of numbers of Pacific halibut observed in that survey (Fig. 30, Sadorus et al. 2017a).

Fishery-dependent data

Commercial fishery landings

An annual estimate of total mortality of Pacific halibut from all sources is required for all stock assessment and related analyses. Removals can be categorized into five major components: fishery landings, fishery wastage (a combination of sub-legal and legal-sized fish), sport (recreational), personal use or subsistence removals, and bycatch of Pacific halibut in fisheries targeting other species (Fig. 31).

Landings of Pacific halibut from the directed fishery are documented through the use of commercial fish tickets, reported to the IPHC (Goen et al. 2017). From 1981 to the present, these landings are fully delineated by Regulatory Area (including all of the portions of Area 4; Fig. 32). Notably, coastwide fishery landings increased from 2014-16, the first increases since 2003. Prior to 1981, landings are available only in aggregated form for all of Regulatory Area 4. Landings from 1935-80 are not currently included in the IPHC's database; however previous analysts have left a number of 'flat files' which appear to correspond well with tables published in technical reports, and other IPHC documents. Because the raw data are not able to be reprocessed directly, the landings estimates prior to 1981 are more uncertain than those after 1981. Historical landings prior to 1935 were reconstructed within current regulatory areas from summaries by historical statistical areas (Bell et al. 1952). Reported landings of Pacific halibut begin in 1888; however, already over one million pounds were being landed per year at that time. The reconstruction by regulatory area of total landings included some use of ratios between Areas 2A and 2B among adjacent years for ambiguous records, therefore the area-specific distributions are therefore more uncertain than the total landings. Several patterns emerge from the longer time series of landings including: the period of substantially reduced fishing in the 1970s in all areas, and the sequential exploitation of Areas 2, 3, and 4 over the entire time series (Table 2, Fig. 33).

Sport (recreational) removals

Sport or recreational removals are reported to the IPHC by the various agencies in charge of managing these fisheries, including Alaska Department of Fish and Game, the Department of Fisheries and Oceans Canada, and the states of Washington, Oregon, and California (Dykstra 2017a). The scientific basis for data collection programs, analyses, and the quality of the subsequent estimates vary considerably by year and source. In 2014, the IPHC began including estimates of the mortality of released fish in the total recreational removals. It is generally assumed that there was little sport fishing for Pacific halibut prior to the mid-1970s. Sport removals have grown rapidly since that time, with peak harvests estimated at over 10 million pounds annually during the mid-2000s. They have been reduced in recent years as the IPHC has lowered stock-wide mortality (Fig. 34). Catch sharing plans (since 2014) tie the charter removals in Areas 2C and 3A to fishery catch limits set by the IPHC. Among Regulatory Areas, Area 3A represents over half of the total removals, with Areas 2C, 2B, and 2A each contributing somewhat less (in declining order).

Personal use or subsistence removals

Subsistence harvest estimates are provided to the IPHC by the DFO and NMFS (Erikson 2017, Goen 2017). Estimates are not generated annually in all cases, and therefore some values are applied through intervening years until the next estimate is made available. This has been the case for the most recent several years. There are currently no estimates available prior to 1991. The time-series created from these estimates is relatively noisy, but occurs on a scale much smaller (< 2 million lbs; ~900 t) than other critical inputs to the analyses (Fig. 35).

Commercial fishery wastage

'Wastage' describes all mortality of Pacific halibut that occurs during the directed fishery, but that does not become part of the landed catch. There are three main sources of wastage: 1) fish that are estimated to have been captured by fishing gear that was subsequently lost during fishing operations, 2) fish that are discarded for regulatory reasons (e.g., the vessel's trip limit or harvester's IFQ limit have been exceeded), and 3) fish that are captured and discarded because they are below the legal size limit of 32 inches (81.3 cm). The methods applied to produce each of these estimates differ due to the amount and quality of information available (see Goen and Stewart 2017).

Based on these methods, wastage in the commercial fishery is estimated to have been highest in the late 1980s, subsequently declining (particularly in Area 3A in 1995 when the derby fishery was converted to a quota system), and then increasing from 1995 to 2010 as the size-at-age of Pacific halibut declined and more fish at older ages remained below the minimum size limit (Fig. 36, upper panel). The estimates of wastage cannot be delineated within Regulatory Area 4 prior to 1981, but there is very little wastage estimated prior to that time (Fig. 36, lower panel).

Bycatch in non-target fisheries

The estimated bycatch from non-target fisheries by regulatory area is reported to the IPHC by the NMFS and DFO on an annual basis (Dykstra 2017b). These estimates vary greatly in quality and precision depending upon year, fishery, type of estimation method, and many other factors. Bycatch has been delineated among Areas 4A, 4B, and 4CDE only from 1990 to the present, during which time it has declined from a peak of over 20 million lbs (~9,070 t) to a projected value of approximately 7.1 million lbs (~3,220 t) in 2016 (Fig. 37, upper panel). This total in 2016 represents the smallest estimate since the beginning of foreign industrial fishing in Alaska in the early 1960s. Over the last several years bycatch has generally increased in Area 3A (but down slightly in 2016), and from 2014 to 2016 bycatch in Area 4 decreased by 2.1 million lbs (~950 t; Fig. 37, lower panel), with most of this decrease in Area 4CDE. Prior to 1991, available bycatch estimates are aggregated for all of Area 4. From the 1960s to 1990s, annual values were variable with a peak in the early 1960s corresponding to the peak of foreign fishing in (currently) Alaska waters, primarily Areas 3A and 3B. There was likely less bycatch prior to the development of the foreign fishery in U.S. waters in the early 1960s; however, bycatch estimates are only available from 1962 to the present.

Summary of total Pacific halibut removals

Recent aggregate total removals from all sources reveal that although the directed commercial fishery represents the majority of the anthropogenic mortality, other sources, including bycatch and sport removals, tend to contribute a larger proportion when the total is lower (Figs. 38-39). Total removals in 2016 were estimated to be 41.9 million lbs (~19,000 t), down slightly from 2015 and well below the 100-year average of 63 million lbs (~29,000 t). Recent total removals from all sources by regulatory area reveal that Area 3A has been the dominant contributor to total mortality throughout the last five decades, but that Area 3A and 3B represent a smaller fraction of the total in recent years than in previous decades (Table 3, Fig. 40).

The full time-series of estimated removals illustrates that all four of the major peaks in the commercial fishery mortality have been of similar magnitude (around 70 million lbs, ~31,000 t) but that each peak has been larger than the previous with regard to total mortality from all sources (Table 4, Fig. 41). When the removals by source are compared among regulatory areas, there are a number of differing patterns in magnitude and distribution (Figs. 42-44).

Fishery catch-rate and biological data

A relatively simple approach is employed to calculate the annual index of fishery WPUE and to summarize fishery-dependent biological information (Fig. 45), with the most important missing component being the lack of sex-specific biological observations due to the dressing of Pacific halibut at sea.

Directed fishery WPUE

Commercial fishery logbook data is collected by port samplers, and reported directly to the IPHC by fishermen. This dataset represents a valuable source of information about many aspects of the commercial fishery, including seasonal and spatial patterns, gear usage, and other details. The data that are included in the current fishery WPUE standardization are: the Regulatory Area of fishing (regardless of the port of delivery), the type of fishing gear used (only fixed-hook data are used in Areas 2C, 3A, 3B, 4A, 4B, 4C, 4D; both fixed-hook and snap gear are used in Areas 2A and 2B), the year of fishing (some logbooks are not obtained by port samplers until the following year), the number of skates fished (excluding any gear that was lost), the spacing of the hooks, the number of hooks on each skate, and the pounds of legal-sized Pacific halibut captured and landed. Only sets specifically targeting Pacific halibut are included in the analysis and all sets with hook-spacing of less than four feet are assumed to be non- Pacific halibut targeting, except in Area 2A.

The fishery catch-rates are calculated based on the catch (in weight) relative to the amount of gear deployed at each station. Effort for each set is standardized to an effective skate (*ES*) that is 1,800 feet long, with 100 hooks (and therefore an 18-foot average spacing), based on the number of skates fished (*S*), the average number of hooks fished per skate (N_h), and the hook-spacing (H_s; Fig. 46) based on the relationship given by Hamley and Skud (1978):

$$ES = S \cdot \left(\frac{N_h}{100}\right) \cdot 1.52 \cdot \left(1 - e^{-0.06 \cdot H_s}\right)$$

The sum of the catch weight (*C*) for all sets (*s*) reported from a Regulatory Area (*a*) each year (*y*) is divided by the sum of the effective skates to obtain the total WPUE, or index (*I*):

$$\bar{I}_{a,y} = \frac{\sum_{s=1}^{Nsets} C_{s,a,y}}{\sum_{s=1}^{Nsets} ES_{s,a,y}}$$

Due to the small number of fixed-hook sets in regulatory Areas 2A and 2B, snap gear is included in the calculation for these areas. This is done by dividing the snap gear effort by a factor of 1.35 (Clark 2002). A detailed exploratory analysis of the logbook standardization data and methods was completed during 2014 (Monnahan and Stewart 2015), which suggested future analyses may be able to include all logbook records in all Regulatory Areas regardless of gear type; this research is ongoing. There are too few logs available on an annual basis from Area 4E to include that regulatory area in the WPUE calculations.

These annual area-specific mean catch-rates are then weighted by the geographic extent of suitable depths occupied by Pacific halibut within each Regulatory Area (g_a, 0-400 fathoms; 0-732 m) relative to the entire coast (Fig. 47). The weighted values are then summed to generate a coast-wide index of abundance:

$$I_y = \sum_{a=1}^{Areas} \bar{I}_{a,y} * \frac{g_a}{\sum_{a=1}^{Areas} g_a}$$

This approach is consistent with the concept that the commercial WPUE is also a 'survey' of the stock and therefore the estimates are a proxy for density, but diverges from the common approach of weighting the commercial WPUE from each area by the catch in that area relative to the total. It may be preferable in the future to explore the use of catch- instead of geographic-weighting.

The final verified record of logbooks available approximately 10-12 months after the end of the annual fishing season differs from the preliminary data available in November and used in the stock assessment each year. Differences reflect the inclusion of logbooks that were not collected by port samplers during the year of fishing (and subsequently mailed in to the IPHC, or collected by port samplers during the following fishing season), as well as logbooks that had been collected but were not available for analysis (the fishing season extends until early November; the stock assessment data are shortly after). In previous years, these changes almost always led to a reduction in the index from preliminary values; however additional emphasis on in-season data entry throughout the 2015 and 2016 seasons has reduced the amount of change and the consistency in direction (for 2015 some areas increased and some decreased when compared to preliminary estimates). Because the data are always incomplete at the time of the assessment, the variance of the terminal year of the WPUE series is inflated by a factor of two. Therefore, the <1% coastwide increase currently estimated for 2016 relative to 2015 (Table 5, Fig. 48) should be interpreted with caution and tempered by inspection of previous trends, particularly at the area-specific level.

Recent trends in the commercial WPUE series differ substantially among regulatory areas and, in some cases, with those observed in the O32 fishery-independent setline survey. The central and Eastern portions of the fishery (Areas 2B-4A) all showed small increases from 2015 to 2016 ranging from 1% in 3A to 9% in 2B (Fig. 48). In contrast to the setline survey, Area 2A showed a substantial decline (47%) from 2015 to 2016, despite a reasonably complete sample size; however, this Area is the only derby-style fishery (both tribal and non-tribal) and has shown considerable variability among years prior to 2011. Also in contrast to the setline survey, Areas 3A and 3B both showed modest increases from 2014 to 2015-16. Trends have been relatively stable among areas 4B, 4C and 4D over the last five years, despite some inter-annual variability. These areas remain at or very close to historical low catch-rates (Table 5, Fig. 48).

Effort data for years prior to 1981 do not currently exist in the IPHC's database. For historical data, as is the case for other sources of information, there exist flat files from previous analysts that include effort and landed catch by regulatory area. These data have been used for other analyses, and date back to 1907. Prior to 1935, records of effort are reported in various technical and other IPHC reports, and there are a number of differing time-series available. Total catch and total effort were tabulated from Chapman et al. (1962) for the years 1921-1934, and from Thompson et al. (1931), although there are differing series in at least Skud (1975) and several others. The oldest historical records do include even earlier years, but have not been included here pending more detailed investigation. It would be preferable to access and process the historical log data directly from data stored in a database with meta-data, but this is not currently possible.

The most dramatic change in the commercial WPUE time series corresponds to the transition from "J" to circle hooks in 1984 (Fig. 49), although there have been many other changes in the definition of effort over the time series (see synopsis in Leaman et al. 2012). Changes in catch rates prior to the 1980s also reflect the historical progression of the fishery from south to north over much of the time-series (Fig. 33). Despite these caveats, it is clear that catch rates were quite low around the time of the formation of the IPHC (in fact, this was the motivation for the original convention), and again in the late 1970s (Table 5, Fig. 49). Additional uncertainty throughout the historical series is reflected by increased CVs (fixed at 0.1) for all years prior to 1984.

Fishery age distributions

Recent fishery ages are created from otoliths collected by port samplers in proportion to the landings in the ports that are annually staffed by the IPHC (Erikson and Kong 2017). Because of this method, the raw ages can be directly aggregated within each area and year to estimate the age composition of the catch. Port samplers also collect individual lengths, and the average weight within each area can be estimated via the length-weight relationship. Dividing the total commercial catch for each regulatory area and year by the average fish weight gives an estimate of the number of fish captured. To aggregate the proportions-at-age from each area into a coastwide or regional total, each regulatory area is weighted by the numbers of fish in the catch relative to the total number of fish captured over all areas. For the period included in recent stock assessments, the coastwide age distribution displays a very similar pattern to that of the setline survey ages: a very strong 1987 cohort moving through the stock (Fig. 50), followed by catches comprised primarily of 9 to 16 year-old Pacific halibut.

Commercial fishery ages prior to 1991 have been summarized by several previous analysts, in some cases processed originally by one analyst and then subsequently by another (Clark et al. 2000). For this summary, a file produced for the analysis by Clark et al. (2000) was obtained, which included proportions at age by regulatory area from 1935 to 1990. Additional work could be done to verify which of these proportions can and can't be recreated from the current IPHC database. Weighting of the area-specific proportions followed the method applied to the more recent data, first obtaining an average individual weight (in this case by multiplying the proportions at age by the estimated average weight at age from the historical records), and then dividing the total landings by that weight to get an estimate of the number of fish in the landings by year and area. Again following the survey analysis methodology, the numbers in the landings by area were used to weight the proportions-at-age for a coastwide total.

The resultant fishery age-frequency distributions reveal that Pacific halibut in the commercial landings from the 1930s to 1973 (when the current minimum size limit was implemented) have been predominantly age 6 to 14 (Fig. 51). Several strong cohorts can be observed in the data, but none more conspicuous or persisting longer than the 1987 cohort. When the fishery age data are aggregated by geographic region, a similar pattern emerges to that seen in the setline survey data: a greater proportion of older Pacific halibut in Areas 4 and 4B than in Areas 2 and 3, but a similar overall age over which much of the catch has been taken and clear evidence that the 1987 cohort was very strong across the entire range of the population (Figs. 52-54).

Fishery weight-at-age

Both lengths and otoliths are collected by port samplers, and the lengths can be converted into individual weight estimates. Individual fish weights are also now routinely collected by port samplers (Webster and Erikson 2017), and this information will likely be included directly in future calculations and summaries of fishery-dependent data sources. At present, no sex-specific information is available from port samples; however progress toward a marking program is ongoing (Loher et al. 2017). The recent average weight of a landed Pacific halibut has been the highest (around 30+ lbs, 13.6 kg) in Area 2C, has been reasonably flat since 2011 in Area 3A and increasing in the last two years in Area 3B (Fig. 55). The coastwide trend has increased slightly over the last four years, but remains lower than the last several decades. These observations accurately reflect the fishery landings, but combine the relative influences of weight-at-age, age- and sex-structure, as well as selectivity relative to the underlying population.

Historical observations of average weight are more problematic. Specifically, from 1963-1990 the IPHC did not collect individual lengths from the commercial landings. It was thought at the time that otoliths measurements could be used to adequately estimate the body size of the fish (Southward 1962), and therefore the weight. Subsequent investigation of the relationship between otolith measurements and individual length (Clark 1992) resulted in the resumption of length sampling in 1991. For this reason, the weights-at-age for most of the historical period should be considered much more uncertain than recent observations. Despite these considerations, there is a clear pattern of increasing fish size in the landings estimated from the 1930s through the 1970s, followed by a subsequent decline to the present (Fig. 56). Also clearly visible is the effect of the implementation of the 32 inch minimum size limit in 1973.

Following the same method applied to the age-composition data (weighting the historical weight-at-age for each regulatory area by the number of fish in the landings for that area), a coastwide weight-at-age can be constructed for the entire time-series. Unfortunately, this series is not sex-specific due to the dressing of fish at sea prior to sampling by port samplers. However, there are similar trends for the best represented ages (8-16) over the historical period. One way to investigate these patterns is to divide the time series of weight-at-age for each age relative to the first year in which we have a coastwide estimate from survey data (1997). Only legal-sized fish from the survey catch are included in these weights-at-age in order to make them comparable to fishery landings. These deviations show very similar temporal patterns, despite expected differences on an absolute scale (Fig. 57). As a proxy for sex-specific weights-at-age for the entire time-series, the survey weights-at-age from 1997 are scaled by the time series of annual deviations calculated from the fishery data. This implicitly assumes that male and female Pacific halibut have experienced similar trends in size-at-age, and recent data that are available by sex support this assumption. The resulting reconstructed coastwide mean weights-at-age clearly show an increase in the late 1970s and subsequent decrease toward present estimates (Fig. 58).

The same methods were also used to estimate trends in weight-at-age separated by geographic areas (2, 3, 4, and 4B). The results indicate that changes in Area 2 have been less pronounced than the very large decrease in fish size observed for Area 3 from the 1950s through the 1990s and that Area 4 has shown a much more muted historical pattern (Fig. 59). The relative scalar for Area 4 is only slightly above a value of one for most of the historical period, and the smallest values occur in the most recent years. No historical data predating the setline survey were available from the commercial fishery in Area 4B. The Area 4 weight-at-age arrays were therefore used as input for both Area 4 and Area 4B.

Recreational fishery age distributions

Age distributions sampled from the recreational catch were included in the stock assessment models for the first time in 2015. Otoliths from recreationally caught Pacific halibut in regulatory Area 3A have been routinely collected by ADF&G, and the ages read by IPHC staff. Estimated numbers-at-age for the years 1994-2013 were weighted by port within Area 3A, and summarized by Scott Meyer (ADFG, pers. comm.). These data showed a variable but generally larger proportion at ages younger than age 5, and smaller proportion greater than age 15 (Fig. 60) compared to the coastwide setline survey over a similar time-period (Fig. 10). The recreational data also contained a few Pacific halibut at ages 2-3, younger than any observed in the setline survey. The observation of extremely young Pacific halibut is somewhat surprising, as trends in size-at-age indicate that some of the smallest fish for their age across the coast are currently observed in Area 3A, so that area might be expected to have fewer very young fish in the recreational harvest if selectivity were similar to that of the setline survey. These data are not geographically comprehensive; however, recreational removals from Area 3A represent around half of the coastwide recreational total in recent years. Currently, there are no additional age data from the recreational fisheries in other regulatory areas, but such data could be included with those from Area 3A if they become available in the future.

Age distribution of bycatch removals

The length-distribution of Pacific halibut caught as bycatch in fisheries targeting other species is reported to the IPHC each year by the National Marine Fisheries Service (NMFS; for Alaska and Washington-Oregon-California) and Fisheries and Oceans Canada (DFO; for British Columbia). Historically, the raw length frequencies are summarized by target fishery within gear type (i.e., trawl, hook-and-line, and pot), then aggregated in order to better represent the differing contributions and sampling rates for each fishery. Weighted length-frequencies of the estimated bycatch are used in the annual harvest policy calculations and catch tables specifically to delineate O26 and U26 removals. In order to evaluate these data directly in the context of the stock assessment, they first need to be converted to age-distributions. Annual age-length keys were produced from the NMFS survey data for the years 1998-2015, and the global key used for prior years and 2016. Coastwide aggregate bycatch lengths were summarized into predicted ages via these annual age-length keys. Estimated bycatch ages showed a mode (or modes) between age-3 and age-10, with up to one-third of the total age distributions represented by Pacific halibut age-4 or less in some years (Fig. 61). Both the 1987 year-class and the strong 2004-05 year classes observed in the NMFS trawl ages are also present in the estimated distributions for the coastwide bycatch. This is not surprising, since the majority of this bycatch occurs in Area 4.

Auxiliary inputs

Several additional sources of information are included in the stock assessment or related analyses and treated as data, even though they represent the products of analyses themselves. These are briefly summarized here but considerable additional background material exists.

Weight-length relationship

The weight-length relationship for Pacific halibut was developed in 1926, re-evaluated in 1991 (Clark), and has been applied as standard practice for al years of IPHC management. The relationship between fork length (L_f), and individual net (headed and gutted) weights (W_n) is given by:

$$W_n = 0.00000692 \cdot {L_f}^{3.24}$$

This relationship reflects the slightly greater than cubic increase in weight with increasing length (Fig. 62). In 2013, the IPHC staff initiated a program to begin sampling individual weights during port sampling. Since 2015 this program has included data collection on survey vessels and during routine port sampling in almost all ports; recent results are reported in Webster and Erikson

(2017). Over the next several years these data should allow for a reanalysis of the length-weight relationship, as well as an improved understanding of the differences in measurements collected on freshly dead fish, fish that have been stored on ice, as well as the relative contributions of head-weights, ice and slime on standardization to net weight.

Maturity schedule

The maturity schedule for Pacific halibut has been investigated several times historically, and maturity-at-age found to be very stable despite long-term changes in length- and weight-at-age (Clark and Hare 2006). Estimates of the age at which 50% of female Pacific halibut are sexually mature average 11.6 years among regulatory areas, with very few fish mature at ages less than five and nearly all fish mature by about age 17. The maturity schedule used for stock assessment has not been updated in recent years, and it is represented by a logistic fit that is truncated below age 8 (Fig. 63).

Ageing bias and imprecision

Ages are often treated and referred to as 'data', however they represent estimates of age based (most commonly) on the counting the rings formed annually on otoliths. These estimates are therefore subject to both bias and imprecision depending on the method employed to obtain them. Pacific halibut tend to be relatively easy to age (compared to longer-lived groundfish), and historical estimates of the imprecision of the standard method of 'break-and-bake' ageing showed that the method was very precise (Clark 2004a, 2004b, Clark and Hare 2006). Validation of the method relative to actual age has been performed via analysis of radiocarbon levels observed in known-age otoliths, and the relationship has since been used as the standard for North Pacific groundfish species (Piner and Wischniowski 2004).

Prior to 2002, surface ageing was employed as the primary tool for ageing Pacific halibut, and this method is known to be biased for older individuals and less precise than other methods when applied to many marine species. Estimates of bias and imprecision for break-and-bake and surface ages were updated in 2013 based on re-aging of setline survey samples from 1998 (Stewart 2014). Analysis of surface ages from each decade back to the 1920s also corroborated those results (Forsberg and Stewart 2015).

Movement rates among geographic regions

Development of spatially explicit stock assessment and Management Strategy Evaluation (MSE) operating models requires an understanding of the rates of movement among geographic regions. Current understanding of adult movement rates for most areas is reasonably well understood, based on extensive historical and more recent PIT tagging studies (Valero and Webster 2012). However, previous summary of these data has been conducted by specific regulatory area, and detailed analysis of these data was originally based on the length of the tagged Pacific halibut (Webster et al. 2013). Webster (2015a; and extended analysis) has provided these rates as a function of age and by geographic region. For Pacific halibut less than age-5, most of the available data come from historical studies that used trawl gear (rather than longline gear) to capture fish for tagging (Valero and Webster 2012). Hilborn et al. (1995) used data from studies conducted in the 1980s to estimate movement parameters for juveniles among specific regulatory areas within geographic Areas 2 and 3 (Table 14 of their document). These data suggest relatively high rates of 'downstream' movement to the east and south. Similar results are unavailable for

Area 4 or 4B, although raw recovery rates from juvenile Pacific halibut tagged in the Bering Sea and Aleutians suggest appreciable movement to all other regulatory areas over 5-10 years of life (Webster 2015b). The lack of data from Area 4 is particularly problematic, given that this is the area where the greatest abundance of 2-4 year old Pacific halibut are observed (Sadorus et al. 2015), and therefore assumptions about movement rates will be most important.

In 2015, this varied information was assembled into a single framework representing the IPHC's current working hypothesis regarding movement-at-age among regions. Key assumptions in constructing this hypothesis included: ages 0-1 do not move, most of the young Pacific halibut reported in Hilborn et al. (1995) were aged 2-4, movement generally increases from ages 2-4, age 2 Pacific halibut cannot move from Area 4 to Area 2 in a single year, and that relative movement rates of Pacific halibut age 2-4 to/from Area 4 are similar to those observed for 2-4 year-old Pacific halibut compared to older Pacific halibut in Area 3. Based on these assumptions, appreciable emigration is estimated to occur from Area 4, decreasing with age. Pacific halibut age-2 to age-4 move from Area 3 to Area 2 and from Area 4B to Areas 3 and 2, and some movement of older Pacific halibut is estimated to occur from Area 2 back to Area 3 (Fig. 64).

Pacific Decadal Oscillation

Previous research identified a strong correlation between the environmental conditions in the northeast Pacific Ocean, specifically the Pacific Decadal Oscillation (PDO; Mantua et al. 1997) and recruitment of Pacific halibut to the commercial fishery during the 1900s. A description of ongoing PDO research as well as access to the time-series of estimates can be found at: http://jisao.washington.edu/pdo/. For Pacific halibut, the positive 'phase' of the PDO (years up to and including 1947 and 1977-2006) and subsequent recruitment of juveniles into the commercial fishery appears to be correlated (Clark et al. 1999, Clark and Hare 2002). Recent reinvestigation of this analysis revealed that the correlation still appears strong using all available data (Stewart and Martell 2016). It is therefore worthwhile to monitor the recent trends in the PDO time series for qualitative purposes, as this represents some of the only information available related to juvenile Pacific halibut abundance prior to their entry into the survey and fishery around age-8-10. Inspection of the most recent PDO values indicates that deviations from 2006-2013 were negative, representing the longest period of negative annual values observed since the late 1970s. Highly positive values were observed over 2014-16 (Fig. 65); however, these values should be interpreted cautiously, as many other environmental indicators were highly anomalous, and it is very unclear whether these years represent comparable conditions to previous PDO observations.

Conclusions

Despite the heterogeneous nature of the various datasets, there is a considerable quantity of historical data available for Pacific halibut, perhaps more than for any other single groundfish species in the region. The IPHC has the benefit of an extremely long time-series of data collection, a high degree of cooperation from the commercial fleet, and therefore a unique resource for historical fishery and biological patterns in the northeast Pacific Ocean. The data themselves, after accounting for important known changes in fishery and survey activities, are remarkably coherent and potentially highly informative for stock assessment, harvest policy, and MSE analyses.

Summary data processing in 2016

This document does not attempt to describe all previous data sources and processing methods used for stock assessment. It is intended to provide an overview of what might be considered current 'best practices'. One important change to previously employed methods is:

- Bycatch length-frequency estimates were recalculated, using a more consistent stratification of target fishery within gear type, following the method previously applied to the 2014 data.

Data sources for future analysis and potential research projects

This section represents a 'laundry-list' of potential extensions to current efforts, as well as new analyses that could benefit the Pacific halibut stock assessment or related analyses in the future. It is not a prioritized list, nor is it to be comprehensive: there are certainly other datasets not listed here but potentially available for analysis. A number of the projects are already underway.

- The IPHC is continuing research on sampling the sex of commercial fish that have been dressed at sea via both genetic and direct voluntary marking projects (Drinan et al. 2017, Loher et al. 2017).
- The work of Monnahan and Stewart (2015) modelling commercial fishery catch rates has been extended to include spatial effects, and will be evaluated in the future to determine if it may be a more robust estimator of annual trends than the raw WPUE calculations currently used in the stock assessment models.
- Reevaluation of the historical length-weight relationship to determine whether recent changes in length-at-age are also accompanied by changes in weight-at-length and how this may change estimates of removals over time. Webster and Erikson (2017) represents the most current information on this project.
- A historical investigation on the factors influencing observed size-at-age, and ageing of additional samples from key periods and areas to support this analysis is ongoing at the IPHC.
- There is the potential that trawl surveys, particularly the Bering Sea trawl survey, could provide information on recruitment strengths for Pacific halibut several years prior to currently available sources of data. Analyses of these data are ongoing in the context of spatially explicit models.
- The NMFS conducts ichthyoplankton surveys in the southwest Bering Sea that could be investigated with regard to potential correlation of planktonic Pacific halibut with the distribution and/or abundance of Pacific halibut spawning biomass. In 2015, a joint IPHC-NMFS project was initiated to investigate the relationship between ichthyoplankton abundance and distribution and subsequent abundance of 1-3 year old Pacific halibut.
- Mapping of survey catch rates and biological observations is an ongoing project at the IPHC. This should provide greater ability to evaluate and interpret trends in the survey data in the future.
- There is a vast quantity of archived historical data that is currently inaccessible until organized, keypunched and formatted into the IPHC's database with appropriate meta-data. Information on historical fishery landings, effort, and age samples would provide a much clearer (and more reproducible) perception of the historical period.

- Additional efforts could be made to reconstruct estimates of personal use or subsistence harvest prior to 1991.
- NMFS observer data from the directed Pacific halibut fleet in Alaska could be evaluated for use in updating DMRs and the age-distributions for wastage when it becomes available and is believed to adequately represent the commercial fishery.
- Historical bycatch length frequencies and mortality estimates need to be reanalyzed accounting for sampling rates in target fisheries and evaluating data quality over the historical period. This work is ongoing at the IPHC.
- Updated maturity studies, including histological evaluation are ongoing at the IPHC.

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Table 1. Time-series of setline survey WPUE by regulatory Area (O32; net lb/skate). Years prior to 1984 are based on surveys conducted with "J" hooks, years prior to 1998 on mean catch-rate and years 1998+ on the space-time model (see Webster 2017).

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
1977	NA	13.7	NA	58.4	NA	NA	NA	NA	NA
1978	NA	19.1	NA	26.9	NA	NA	NA	NA	NA
1979	NA	NA	NA	41.0	NA	NA	NA	NA	NA
1980	NA	25.5	NA	76.2	NA	NA	NA	NA	NA
1981	NA	16.5	NA	131.4	NA	NA	NA	NA	NA
1982	NA	20.6	113.7	130.3	NA	NA	NA	NA	NA
1983	NA	18.0	142.2	119.0	NA	NA	NA	NA	NA
1984	NA	57.4	259.6	361.2	NA	NA	NA	NA	NA
1985	NA	41.7	260.5	377.5	NA	NA	NA	NA	NA
1986	NA	37.8	282.6	305.1	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	95.7	NA	261.1	NA	NA	NA	NA	NA
1994	NA	NA	NA	255.1	NA	NA	NA	NA	NA
1995	22.1	143.9	NA	316.4	NA	NA	NA	NA	NA
1996	24.0	141.2	309.1	313.3	347.0	NA	NA	NA	NA
1997	25.8	129.2	400.2	326.4	408.5	275.3	281.9	22.4	135.8
1998	38.3	101.8	280.5	308.2	584.4	411.6	258.3	21.2	146.3
1999	37.8	86.1	227.4	284.2	603.1	366.4	213.8	20.6	136.9
2000	36.9	102.0	244.5	340.2	514.2	365.8	192.0	21.4	138.1
2001	35.4	115.4	266.4	334.1	420.0	284.3	143.5	20.6	125.0
2002	27.7	112.7	291.1	376.2	337.1	250.9	108.4	18.0	119.5
2003	25.4	83.4	236.2	324.8	341.5	214.9	89.7	16.6	105.7
2004	26.8	75.0	167.6	363.6	282.5	183.9	80.0	14.9	100.1
2005	27.3	77.0	180.9	330.9	219.2	161.9	77.0	12.2	89.2
2006	21.4	72.1	164.5	286.1	220.4	134.1	85.1	13.4	82.2
2007	18.9	75.5	160.6	268.5	215.1	118.8	100.1	11.6	78.7
2008	19.4	79.2	153.1	227.1	171.2	129.3	103.1	11.7	71.0
2009	15.4	87.6	136.4	184.9	160.0	117.2	85.3	12.4	63.7
2010	19.6	90.5	139.7	172.6	129.9	97.2	74.7	11.9	58.7
2011	23.9	92.9	172.3	169.9	112.2	91.9	74.6	11.2	57.9
2012	22.9	105.5	218.2	192.4	110.7	92.1	62.4	11.8	62.8
2013	22.2	104.0	223.5	149.4	93.7	74.2	65.8	11.8	55.6
2014	23.5	101.2	225.5	156.6	90.3	77.9	56.6	13.1	56.6
2015	29.3	113.9	230.6	145.5	97.6	74.3	56.8	14.2	57.6
2016	27.8	115.9	255.2	159.8	109.7	68.8	55.9	14.1	60.8

Table 2. Time-series of fishery landings by regulatory Area (million lb, net wt.).

Year	2A	2B	2C	3A	3B	4	4A	4B	4CDE	Total
1888	0.07	0.89	0.50	0.00	0.00	NA	NA	NA	NA	1.47
1889	0.07	0.79	0.44	0.00	0.00	NA	NA	NA	NA	1.29
1890	0.07	0.84	0.47	0.00	0.00	NA	NA	NA	NA	1.37
1891	0.11	1.30	0.73	0.00	0.00	NA	NA	NA	NA	2.13
1892	0.14	1.69	0.94	0.00	0.00	NA	NA	NA	NA	2.77
1893	0.16	1.96	1.09	0.00	0.00	NA	NA	NA	NA	3.22
1894	0.19	2.29	1.28	0.00	0.00	NA	NA	NA	NA	3.76
1895	0.21	2.59	1.45	0.00	0.00	NA	NA	NA	NA	4.25
1896	0.27	3.31	1.84	0.00	0.00	NA	NA	NA	NA	5.42
1897	0.33	4.02	2.24	0.00	0.00	NA	NA	NA	NA	6.59
1898	0.39	4.73	2.64	0.00	0.00	NA	NA	NA	NA	7.77
1899	0.45	5.45	3.04	0.00	0.00	NA	NA	NA	NA	8.94
1900	0.68	8.17	4.56	0.00	0.00	NA	NA	NA	NA	13.41
1901	0.90	10.90	6.08	0.00	0.00	NA	NA	NA	NA	17.87
1902	1.13	13.62	7.60	0.00	0.00	NA	NA	NA	NA	22.34
1903	1.27	15.37	8.57	0.00	0.00	NA	NA	NA	NA	25.21
1904	1.41	17.12	9.55	0.00	0.00	NA	NA	NA	NA	28.08
1905	1.11	13.41	7.48	0.00	0.00	NA	NA	NA	NA	22.00
1906	1.81	21.95	12.24	0.00	0.00	NA	NA	NA	NA	36.00
1907	2.52	30.48	17.00	0.00	0.00	NA	NA	NA	NA	50.00
1908	2.55	30.86	17.21	0.00	0.00	NA	NA	NA	NA	50.62
1909	2.58	31.23	17.42	0.00	0.00	NA	NA	NA	NA	51.23
1910	2.61	31.61	17.63	0.00	0.00	NA	NA	NA	NA	51.85
1911	2.87	34.71	19.36	0.00	0.00	NA	NA	NA	NA	56.93
1912	3.00	36.29	20.24	0.86	0.04	NA	NA	NA	NA	60.43
1913	2.79	33.80	18.85	10.58	0.52	NA	NA	NA	NA	66.54
1914	2.24	27.11	15.12	21.87	1.08	NA	NA	NA	NA	67.43
1915	2.22	26.84	14.97	23.31	1.15	NA	NA	NA	NA	68.48
1916	1.53	18.46	10.30	18.56	0.92	NA	NA	NA	NA	49.76
1917	1.55	18.78	10.47	16.96	0.84	NA	NA	NA	NA	48.60
1918	1.32	16.02	8.93	10.88	0.54	NA	NA	NA	NA	37.69
1919	1.34	16.22	9.05	12.90	0.64	NA	NA	NA	NA	40.14
1920	1.62	19.73	11.01	13.59	0.67	NA	NA	NA	NA	46.62
1921	3.39	23.37	10.22	14.75	0.73	NA	NA	NA	NA	52.46
1922	2.61	19.02	9.22	11.63	0.02	NA	NA	NA	NA	42.49
1923	2.62	16.71	9.72	21.60	0.67	NA	NA	NA	NA	51.32
1924	1.82	15.14	9.86	24.82	1.50	NA	NA	NA	NA	53.14
1925	2.20	13.65	7.99	22.16	4.66	NA	NA	NA	NA	50.66
1926	2.32	16.12	7.17	21.01	5.85	NA	NA	NA	NA	52.47
1927	2.62	14.09	7.42	22.62	8.20	NA	NA	NA	NA	54.95
1928	2.27	16.63	7.58	22.54	5.25	NA	NA	NA	NA	54.26
1929	2.18	13.77	9.85	22.27	8.86	NA	NA	NA	NA	56.92
1930	1.58	12.12	8.53	18.19	9.09	NA	NA	NA	NA	49.51
1931	1.63	13.53	7.39	14.61	7.06	NA	NA	NA	NA	44.22
1932	1.90	13.25	7.74	16.71	4.89	NA	NA	NA	NA	44.49
1933	1.75	13.37	8.15	19.67	3.97	NA	NA	NA	NA	46.91
1934	2.45	14.12	7.68	15.88	4.58	NA	NA	NA	NA	44.72
1935	1.77	14.21	7.58	19.96	3.82	0.00	NA	NA	NA	47.34
1936	0.90	13.67	8.75	20.09	5.52	0.00	NA	NA	NA	48.92
1937	0.92	15.29	7.87	20.47	5.00	0.00	NA	NA	NA	49.54
1938	0.95	16.00	7.15	20.66	4.79	0.00	NA	NA	NA	49.55
1939	1.36	17.67	6.56	21.16	4.15	0.00	NA	NA	NA	50.90
1940	0.98	17.81	7.62	22.50	4.48	0.00	NA	NA	NA	53.38

Table 2. Continued.

Year	2A	2B	2C	3A	3B	4	4A	4B	4CDE	Total
1941	0.51	16.53	7.25	21.84	6.10	0.00	NA	NA	NA	52.23
1942	0.72	14.37	8.35	21.50	5.46	0.00	NA	NA	NA	50.39
1943	1.24	15.97	8.15	20.51	7.83	0.00	NA	NA	NA	53.70
1944	0.90	15.07	10.38	20.36	6.73	0.00	NA	NA	NA	53.44
1945	0.73	14.58	8.49	20.07	9.52	0.01	NA	NA	NA	53.40
1946	0.90	18.37	9.90	22.40	8.50	0.20	NA	NA	NA	60.27
1947	0.57	17.67	9.50	20.44	7.33	0.19	NA	NA	NA	55.70
1948	0.41	17.67	9.75	19.93	7.50	0.30	NA	NA	NA	55.56
1949	0.62	16.34	9.45	21.12	7.38	0.12	NA	NA	NA	55.03
1950	0.70	17.46	8.84	23.86	6.30	0.08	NA	NA	NA	57.23
1951	0.59	20.04	9.97	20.86	4.54	0.05	NA	NA	NA	56.05
1952	0.62	20.63	9.56	27.27	3.62	0.56	NA	NA	NA	62.26
1953	0.50	23.80	8.41	22.84	3.81	0.48	NA	NA	NA	59.84
1954	0.85	24.90	11.04	29.46	4.21	0.13	NA	NA	NA	70.58
1955	0.61	18.65	8.54	23.06	6.57	0.09	NA	NA	NA	57.52
1956	0.53	20.06	14.51	22.11	9.12	0.26	NA	NA	NA	66.59
1957	0.60	17.69	12.25	22.85	7.43	0.04	NA	NA	NA	60.85
1958	0.52	18.49	11.20	24.52	7.60	2.18	NA	NA	NA	64.51
1959	0.67	16.83	13.03	25.36	11.00	4.31	NA	NA	NA	71.20
1960	0.89	18.16	12.72	21.05	12.90	5.90	NA	NA	NA	71.61
1961	0.50	16.08	12.29	23.07	13.28	4.07	NA	NA	NA	69.27
1962	0.45	15.03	13.24	24.04	13.48	8.62	NA	NA	NA	74.86
1963	0.41	15.52	10.24	22.31	13.98	8.77	NA	NA	NA	71.24
1964	0.28	11.86	7.43	22.56	15.04	2.62	NA	NA	NA	59.78
1965	0.21	11.97	12.07	22.98	14.07	1.88	NA	NA	NA	63.18
1966	0.18	11.04	12.04	25.77	11.05	1.94	NA	NA	NA	62.02
1967	0.20	10.11	9.41	19.66	13.26	2.58	NA	NA	NA	55.22
1968	0.14	10.15	6.11	14.77	15.83	1.60	NA	NA	NA	48.59
1969	0.23	12.82	9.33	20.08	13.92	1.90	NA	NA	NA	58.27
1970	0.16	10.26	9.37	19.91	13.37	1.78	NA	NA	NA	54.84
1971	0.32	9.85	6.61	17.76	11.04	1.08	NA	NA	NA	46.65
1972	0.37	10.13	5.78	16.30	9.28	1.02	NA	NA	NA	42.88
1973	0.23	6.73	5.98	13.50	4.79	0.52	NA	NA	NA	31.74
1974	0.52	4.62	5.60	8.19	1.67	0.71	NA	NA	NA	21.31
1975	0.46	7.13	6.24	10.60	2.56	0.63	NA	NA	NA	27.62
1976	0.24	7.28	5.53	11.04	2.73	0.72	NA	NA	NA	27.54
1977	0.21	5.43	3.19	8.64	3.19	1.22	NA	NA	NA	21.88
1978	0.10	4.61	4.32	10.30	1.32	1.35	NA	NA	NA	22.00
1979	0.05	4.86	4.53	11.34	0.39	1.37	NA	NA	NA	22.54
1980	0.02	5.65	3.24	11.97	0.28	0.71	NA	NA	NA	21.87
1981	0.20	5.66	4.01	14.23	0.45	NA	0.49	0.39	0.31	25.74
1982	0.21	5.54	3.50	13.52	4.80	NA	1.17	0.01	0.25	29.01
1983	0.27	5.44	6.38	14.13	7.76	NA	2.50	1.34	0.58	38.39
1984	0.43	9.05	5.87	19.77	6.69	NA	1.05	1.10	1.01	44.97
1985	0.49	10.39	9.21	20.84	10.89	NA	1.72	1.24	1.33	56.10
1986	0.58	11.23	10.61	32.80	8.82	NA	3.38	0.26	1.95	69.63
1987	0.59	12.25	10.69	31.31	7.76	NA	3.69	1.50	1.69	69.47
1988	0.49	12.86	11.36	37.91	7.08	NA	1.93	1.59	1.17	74.39
1989	0.47	10.43	9.53	33.74	7.84	NA	1.03	2.65	1.26	66.95
1990	0.33	8.57	9.73	28.85	8.69	NA	2.50	1.33	1.59	61.60
1991	0.36	7.19	8.69	22.93	11.93	NA	2.26	1.51	2.22	57.08
1992	0.44	7.63	9.82	26.78	8.62	NA	2.70	2.32	1.59	59.89
1993	0.50	10.63	11.29	22.74	7.86	NA	2.56	1.96	1.73	59.27

Table 2. Continued.

Year	2A	2B	2C	3A	3B	4	4A	4B	4CDE	Total
1994	0.37	9.91	10.38	24.84	3.86	NA	1.80	2.02	1.55	54.73
1995	0.30	9.62	7.77	18.34	3.13	NA	1.62	1.68	1.44	43.88
1996	0.30	9.55	8.87	19.69	3.66	NA	1.70	2.07	1.51	47.34
1997	0.41	12.42	9.92	24.64	9.06	NA	2.91	3.32	2.52	65.20
1998	0.46	13.17	10.20	25.70	11.16	NA	3.42	2.90	2.75	69.76
1999	0.45	12.71	10.14	25.32	13.84	NA	4.37	3.57	3.92	74.31
2000	0.48	10.81	8.45	19.27	15.41	NA	5.16	4.69	4.02	68.29
2001	0.68	10.29	8.40	21.54	16.34	NA	5.02	4.47	3.97	70.70
2002	0.85	12.07	8.60	23.13	17.31	NA	5.09	4.08	3.52	74.66
2003	0.82	11.79	8.41	22.75	17.22	NA	5.02	3.86	3.26	73.14
2004	0.88	12.16	10.23	25.17	15.46	NA	3.56	2.72	2.92	73.11
2005	0.80	12.33	10.63	26.03	13.17	NA	3.40	1.98	3.48	71.82
2006	0.83	12.01	10.49	25.71	10.79	NA	3.33	1.59	3.23	67.98
2007	0.79	9.77	8.47	26.49	9.25	NA	2.83	1.42	3.85	62.87
2008	0.68	7.76	6.21	24.52	10.75	NA	3.02	1.76	3.88	58.57
2009	0.49	6.64	4.96	21.76	10.78	NA	2.53	1.59	3.31	52.05
2010	0.42	6.73	4.49	20.50	10.11	NA	2.33	1.83	3.32	49.72
2011	0.54	6.69	2.45	14.67	7.32	NA	2.35	2.05	3.43	39.51
2012	0.57	5.98	2.69	12.03	5.05	NA	1.58	1.74	2.34	31.99
2013	0.54	6.04	3.03	11.08	4.09	NA	1.23	1.25	1.77	29.04
2014	0.53	5.88	3.42	7.66	2.92	NA	0.91	1.12	1.26	23.70
2015	0.57	5.99	3.77	7.97	2.70	NA	1.37	1.11	1.19	24.67
2016	0.64	6.14	4.01	7.52	2.75	NA	1.38	1.12	1.48	25.03

Table 3. Time-series of total removals by regulatory Area (million lb, net wt.).

Year	2A	2B	2C	3A	3B	4	Total
1888	0.07	0.89	0.50	0.00	0.00	0.00	1.47
1889	0.07	0.79	0.44	0.00	0.00	0.00	1.29
1890	0.07	0.84	0.47	0.00	0.00	0.00	1.37
1891	0.11	1.30	0.73	0.00	0.00	0.00	2.13
1892	0.14	1.69	0.94	0.00	0.00	0.00	2.77
1893	0.16	1.96	1.09	0.00	0.00	0.00	3.22
1894	0.19	2.29	1.28	0.00	0.00	0.00	3.76
1895	0.21	2.59	1.45	0.00	0.00	0.00	4.25
1896	0.27	3.31	1.84	0.00	0.00	0.00	5.42
1897	0.33	4.02	2.24	0.00	0.00	0.00	6.59
1898	0.39	4.73	2.64	0.00	0.00	0.00	7.77
1899	0.45	5.45	3.04	0.00	0.00	0.00	8.94
1900	0.68	8.17	4.56	0.00	0.00	0.00	13.41
1901	0.90	10.90	6.08	0.00	0.00	0.00	17.87
1902	1.13	13.62	7.60	0.00	0.00	0.00	22.34
1903	1.27	15.37	8.57	0.00	0.00	0.00	25.21
1904	1.41	17.12	9.55	0.00	0.00	0.00	28.08
1905	1.11	13.41	7.48	0.00	0.00	0.00	22.00
1906	1.81	21.95	12.24	0.00	0.00	0.00	36.00
1907	2.52	30.48	17.00	0.00	0.00	0.00	50.00
1908	2.55	30.86	17.21	0.00	0.00	0.00	50.62
1909	2.58	31.23	17.42	0.00	0.00	0.00	51.23
1910	2.61	31.61	17.63	0.00	0.00	0.00	51.85
1911	2.87	34.71	19.36	0.00	0.00	0.00	56.93
1912	3.00	36.29	20.24	0.86	0.04	0.00	60.43
1913	2.79	33.80	18.85	10.58	0.52	0.00	66.54
1914	2.24	27.11	15.12	21.87	1.08	0.00	67.43
1915	2.22	26.84	14.97	23.31	1.15	0.00	68.48
1916	1.53	18.46	10.30	18.56	0.92	0.00	49.76
1917	1.55	18.78	10.47	16.96	0.84	0.00	48.60
1918	1.32	16.02	8.93	10.88	0.54	0.00	37.69
1919	1.34	16.22	9.05	12.90	0.64	0.00	40.14
1920	1.62	19.73	11.01	13.59	0.67	0.00	46.62
1921	3.39	23.37	10.22	14.75	0.73	0.00	52.46
1922	2.61	19.02	9.22	11.63	0.02	0.00	42.50
1923	2.62	16.71	9.72	21.60	0.67	0.00	51.32
1924	1.82	15.14	9.86	24.82	1.50	0.00	53.14
1925	2.20	13.65	7.99	22.16	4.66	0.00	50.66
1926	2.32	16.12	7.17	21.01	5.85	0.00	52.47
1927	2.62	14.09	7.42	22.62	8.20	0.00	54.95
1928	2.27	16.63	7.58	22.54	5.25	0.00	54.26
1929	2.18	13.77	9.85	22.27	8.86	0.00	56.93
1930	1.58	12.12	8.53	18.19	9.09	0.00	49.51
1931	1.63	13.53	7.39	14.61	7.06	0.00	44.22
1932	1.90	13.25	7.74	16.71	4.89	0.00	44.49
1933	1.75	13.37	8.15	19.67	3.97	0.00	46.91
1934	2.45	14.12	7.68	15.88	4.58	0.00	44.72
1935	1.77	14.21	7.58	19.96	3.82	0.00	47.34
1936	0.90	13.67	8.75	20.09	5.52	0.00	48.92
1937	0.92	15.29	7.87	20.47	5.00	0.00	49.54
1938	0.95	16.00	7.15	20.66	4.79	0.00	49.55
1939	1.36	17.67	6.56	21.16	4.15	0.00	50.90
1940	0.98	17.81	7.62	22.50	4.48	0.00	53.38

Table 3. Continued.

Year	2A	2B	2C	3A	3B	4	Total
1941	0.51	16.53	7.25	21.84	6.10	0.00	52.23
1942	0.72	14.37	8.35	21.50	5.46	0.00	50.39
1943	1.24	15.97	8.15	20.51	7.83	0.00	53.70
1944	0.90	15.07	10.38	20.36	6.73	0.00	53.44
1945	0.73	14.58	8.49	20.07	9.52	0.01	53.40
1946	0.90	18.37	9.90	22.40	8.50	0.20	60.27
1947	0.57	17.67	9.50	20.44	7.33	0.19	55.70
1948	0.41	17.67	9.75	19.93	7.50	0.30	55.56
1949	0.62	16.34	9.45	21.12	7.38	0.12	55.03
1950	0.70	17.46	8.84	23.86	6.30	0.08	57.23
1951	0.59	20.04	9.97	20.86	4.54	0.05	56.05
1952	0.62	20.63	9.56	27.27	3.62	0.56	62.26
1953	0.50	23.80	8.41	22.84	3.81	0.48	59.84
1954	0.85	24.90	11.04	29.46	4.21	0.13	70.58
1955	0.61	18.65	8.54	23.06	6.57	0.09	57.52
1956	0.53	20.06	14.51	22.11	9.12	0.26	66.59
1957	0.60	17.69	12.25	22.85	7.43	0.04	60.85
1958	0.52	18.49	11.20	24.52	7.60	2.18	64.51
1959	0.67	16.83	13.03	25.36	11.00	4.31	71.20
1960	0.89	18.16	12.72	21.05	12.90	5.90	71.61
1961	0.50	16.08	12.29	23.07	13.28	4.07	69.27
1962	0.45	16.21	13.45	25.96	14.65	12.76	83.47
1963	0.41	16.60	10.45	25.62	16.77	10.81	80.66
1964	0.28	12.96	7.64	31.93	17.30	5.59	75.70
1965	0.21	13.40	12.27	29.08	24.51	5.06	84.54
1966	0.18	12.70	12.25	30.28	19.03	5.34	79.79
1967	0.20	11.76	9.85	24.29	18.16	7.30	71.56
1968	0.14	12.11	6.63	20.25	17.41	7.28	63.81
1969	0.23	15.00	9.79	23.89	15.09	9.50	73.50
1970	0.16	11.73	9.93	23.30	16.21	9.80	71.13
1971	0.32	11.59	7.15	20.74	12.40	14.18	66.37
1972	0.37	11.88	6.54	21.71	10.98	10.69	62.16
1973	0.23	8.24	6.82	17.95	7.49	8.55	49.27
1974	1.00	6.43	6.17	13.50	5.10	8.33	40.54
1975	0.94	9.18	6.93	13.85	4.65	4.28	39.84
1976	0.72	9.51	6.28	14.64	5.20	5.29	41.63
1977	0.70	7.39	3.87	13.02	5.12	4.14	34.24
1978	0.59	6.20	4.82	13.75	3.17	6.38	34.90
1979	0.54	6.84	5.56	17.62	1.33	6.79	38.68
1980	0.52	7.16	4.12	18.44	1.53	9.95	41.72
1981	0.70	7.01	4.87	19.85	2.02	7.62	42.06
1982	0.74	6.60	4.33	18.16	7.04	6.21	43.08
1983	0.81	6.63	7.30	18.15	9.80	8.72	51.41
1984	1.03	10.55	6.86	23.10	8.30	7.89	57.73
1985	1.17	12.33	10.53	24.26	11.86	8.70	68.86
1986	1.40	13.27	12.25	37.92	9.82	11.56	86.22
1987	1.52	14.85	12.31	37.64	9.14	13.00	88.46
1988	1.22	15.28	13.13	46.69	7.40	13.70	97.42
1989	1.29	12.69	11.75	42.11	9.03	12.43	89.29
1990	0.95	11.07	12.42	38.29	11.15	14.36	88.25
1991	0.94	9.76	12.31	34.55	14.48	16.69	88.73
1992	1.15	9.98	12.83	37.11	11.12	17.78	89.97
1993	1.23	13.24	14.36	33.48	9.24	14.39	85.94

Table 3. Continued.

Year	2A	2B	2C	3A	3B	4	Total
1994	1.02	12.03	13.46	35.04	5.46	15.18	82.19
1995	1.17	12.56	10.02	26.33	5.00	13.67	68.75
1996	1.16	11.24	11.52	27.81	5.76	14.09	71.59
1997	1.41	14.12	12.67	33.74	10.82	16.97	89.72
1998	1.95	14.90	13.19	33.81	12.88	17.23	93.96
1999	1.80	14.38	12.45	33.05	15.93	20.01	97.62
2000	1.69	12.55	11.19	28.02	17.34	21.74	92.53
2001	2.00	12.03	10.78	29.75	18.53	21.04	94.14
2002	1.93	14.08	11.09	30.25	19.79	20.35	97.49
2003	1.55	13.90	11.56	32.32	19.64	19.29	98.25
2004	1.72	14.64	14.28	35.61	17.49	16.23	99.96
2005	1.90	15.15	14.41	36.08	14.93	16.93	99.41
2006	2.01	14.96	14.08	34.90	12.68	15.99	94.61
2007	1.76	12.58	12.48	36.71	10.84	15.35	89.72
2008	1.68	10.29	10.29	34.00	12.80	15.15	84.21
2009	1.58	8.71	8.15	30.50	12.88	13.82	75.63
2010	1.22	8.77	7.20	28.85	12.16	13.52	71.71
2011	1.10	8.83	4.00	22.76	9.26	12.74	58.69
2012	1.22	7.85	4.81	18.23	6.75	11.93	50.79
2013	1.17	7.75	5.76	17.53	5.41	10.45	48.07
2014	1.16	7.76	6.05	13.87	4.24	9.23	42.31
2015	1.18	8.02	6.53	14.58	3.59	8.22	42.11
2016	1.31	8.12	6.80	13.73	3.98	7.95	41.89

Table 4. Time-series of estimated removals by source (million lb, net wt.).

Year	Commercial landings	Commercial wastage	Bycatch	Sport	Personal use	Total
1888	1.47	0.00	0.00	0.00	0.00	1.47
1889	1.29	0.00	0.00	0.00	0.00	1.29
1890	1.37	0.00	0.00	0.00	0.00	1.37
1891	2.13	0.00	0.00	0.00	0.00	2.13
1892	2.77	0.00	0.00	0.00	0.00	2.77
1893	3.22	0.00	0.00	0.00	0.00	3.22
1894	3.76	0.00	0.00	0.00	0.00	3.76
1895	4.25	0.00	0.00	0.00	0.00	4.25
1896	5.42	0.00	0.00	0.00	0.00	5.42
1897	6.59	0.00	0.00	0.00	0.00	6.59
1898	7.77	0.00	0.00	0.00	0.00	7.77
1899	8.94	0.00	0.00	0.00	0.00	8.94
1900	13.41	0.00	0.00	0.00	0.00	13.41
1901	17.87	0.00	0.00	0.00	0.00	17.87
1902	22.34	0.00	0.00	0.00	0.00	22.34
1903	25.21	0.00	0.00	0.00	0.00	25.21
1904	28.08	0.00	0.00	0.00	0.00	28.08
1905	22.00	0.00	0.00	0.00	0.00	22.00
1906	36.00	0.00	0.00	0.00	0.00	36.00
1907	50.00	0.00	0.00	0.00	0.00	50.00
1908	50.62	0.00	0.00	0.00	0.00	50.62
1909	51.23	0.00	0.00	0.00	0.00	51.23
1910	51.85	0.00	0.00	0.00	0.00	51.85
1911	56.93	0.00	0.00	0.00	0.00	56.93
1912	60.43	0.00	0.00	0.00	0.00	60.43
1913	66.54	0.00	0.00	0.00	0.00	66.54
1914	67.43	0.00	0.00	0.00	0.00	67.43
1915	68.48	0.00	0.00	0.00	0.00	68.48
1916	49.76	0.00	0.00	0.00	0.00	49.76
1917	48.60	0.00	0.00	0.00	0.00	48.60
1918	37.69	0.00	0.00	0.00	0.00	37.69
1919	40.14	0.00	0.00	0.00	0.00	40.14
1920	46.62	0.00	0.00	0.00	0.00	46.62
1921	52.46	0.00	0.00	0.00	0.00	52.46
1922	42.49	0.00	0.00	0.00	0.00	42.49
1923	51.32	0.00	0.00	0.00	0.00	51.32
1924	53.14	0.00	0.00	0.00	0.00	53.14
1925	50.66	0.00	0.00	0.00	0.00	50.66
1926	52.47	0.00	0.00	0.00	0.00	52.47
1927	54.95	0.00	0.00	0.00	0.00	54.95
1928	54.26	0.00	0.00	0.00	0.00	54.26
1929	56.92	0.00	0.00	0.00	0.00	56.92
1930	49.51	0.00	0.00	0.00	0.00	49.51
1931	44.22	0.00	0.00	0.00	0.00	44.22
1932	44.49	0.00	0.00	0.00	0.00	44.49
1933	46.91	0.00	0.00	0.00	0.00	46.91
1934	44.72	0.00	0.00	0.00	0.00	44.72
1935	47.34	0.00	0.00	0.00	0.00	47.34
1936	48.92	0.00	0.00	0.00	0.00	48.92
1937	49.54	0.00	0.00	0.00	0.00	49.54
1938	49.55	0.00	0.00	0.00	0.00	49.55
1939	50.90	0.00	0.00	0.00	0.00	50.90

Table 4. Continued.

Year	Commercial landings	Commercial wastage	Bycatch	Sport	Personal use	Total
1940	53.38	0.00	0.00	0.00	0.00	53.38
1941	52.23	0.00	0.00	0.00	0.00	52.23
1942	50.39	0.00	0.00	0.00	0.00	50.39
1943	53.70	0.00	0.00	0.00	0.00	53.70
1944	53.44	0.00	0.00	0.00	0.00	53.44
1945	53.40	0.00	0.00	0.00	0.00	53.40
1946	60.27	0.00	0.00	0.00	0.00	60.27
1947	55.70	0.00	0.00	0.00	0.00	55.70
1948	55.56	0.00	0.00	0.00	0.00	55.56
1949	55.03	0.00	0.00	0.00	0.00	55.03
1950	57.23	0.00	0.00	0.00	0.00	57.23
1951	56.05	0.00	0.00	0.00	0.00	56.05
1952	62.26	0.00	0.00	0.00	0.00	62.26
1953	59.84	0.00	0.00	0.00	0.00	59.84
1954	70.58	0.00	0.00	0.00	0.00	70.58
1955	57.52	0.00	0.00	0.00	0.00	57.52
1956	66.59	0.00	0.00	0.00	0.00	66.59
1957	60.85	0.00	0.00	0.00	0.00	60.85
1958	64.51	0.00	0.00	0.00	0.00	64.51
1959	71.20	0.00	0.00	0.00	0.00	71.20
1960	71.61	0.00	0.00	0.00	0.00	71.61
1961	69.27	0.00	0.00	0.00	0.00	69.27
1962	74.86	0.00	8.61	0.00	0.00	83.47
1963	71.24	0.00	9.42	0.00	0.00	80.66
1964	59.78	0.00	15.91	0.00	0.00	75.70
1965	63.18	0.00	21.36	0.00	0.00	84.54
1966	62.02	0.00	17.77	0.00	0.00	79.79
1967	55.22	0.00	16.34	0.00	0.00	71.56
1968	48.59	0.00	15.22	0.00	0.00	63.81
1969	58.27	0.00	15.23	0.00	0.00	73.50
1970	54.84	0.00	16.29	0.00	0.00	71.13
1971	46.65	0.00	19.72	0.00	0.00	66.37
1972	42.88	0.00	19.28	0.00	0.00	62.16
1973	31.74	0.00	17.53	0.00	0.00	49.27
1974	21.31	0.20	19.03	0.00	0.00	40.54
1975	27.62	0.31	11.91	0.00	0.00	39.84
1976	27.54	0.34	13.75	0.00	0.00	41.63
1977	21.88	0.29	11.78	0.29	0.00	34.24
1978	22.00	0.28	12.24	0.38	0.00	34.90
1979	22.54	0.30	15.28	0.56	0.00	38.68
1980	21.87	0.30	18.70	0.85	0.00	41.72
1981	25.74	0.35	14.86	1.11	0.00	42.06
1982	29.01	0.40	12.37	1.30	0.00	43.08
1983	38.39	0.53	10.88	1.62	0.00	51.41
1984	44.97	0.72	10.19	1.84	0.00	57.73
1985	56.10	2.70	7.70	2.36	0.00	68.86
1986	69.63	4.65	8.76	3.18	0.00	86.22
1987	69.47	4.20	11.28	3.51	0.00	88.46
1988	74.39	3.49	14.66	4.88	0.00	97.42
1989	66.95	3.46	13.65	5.23	0.00	89.29
1990	61.60	3.38	17.68	5.59	0.00	88.25
1991	57.08	3.46	19.67	6.51	2.01	88.74

Table 4. Continued.

Year	Commercial landings	Commercial wastage	Bycatch	Sport	Personal use	Total
1992	59.89	2.50	6.18	1.11	20.29	89.97
1993	59.27	2.05	7.73	0.93	15.96	85.94
1994	54.73	2.51	7.07	0.93	16.95	82.19
1995	43.88	0.93	7.46	0.54	15.93	68.75
1996	47.34	1.15	8.08	0.54	14.46	71.59
1997	65.20	1.45	9.03	0.54	13.51	89.73
1998	69.76	1.72	8.59	0.74	13.16	93.96
1999	74.31	1.65	7.38	0.75	13.54	97.62
2000	68.29	1.45	9.01	0.76	13.02	92.53
2001	70.70	1.69	8.10	0.77	12.88	94.14
2002	74.66	1.72	8.01	0.77	12.33	97.49
2003	73.14	2.08	9.35	1.38	12.31	98.25
2004	73.11	2.30	10.71	1.55	12.29	99.96
2005	71.82	2.22	10.86	1.54	12.97	99.41
2006	67.98	2.46	10.20	1.48	12.49	94.61
2007	62.87	2.59	11.47	1.49	11.31	89.72
2008	58.57	2.76	10.68	1.34	10.86	84.21
2009	52.05	2.94	8.79	1.31	10.54	75.63
2010	49.72	3.21	7.85	1.24	9.70	71.71
2011	39.51	2.46	7.10	1.14	8.47	58.69
2012	31.99	1.67	6.78	1.15	9.20	50.79
2013	29.04	1.43	7.63	1.13	8.83	48.07
2014	23.70	1.30	7.19	1.20	8.92	42.30
2015	24.67	1.28	7.46	1.20	7.49	42.11
2016	25.03	1.18	7.38	1.20	7.10	41.89

Table 5. Time-series of commercial fishery WPUE by regulatory Area (net lb/skate). Years prior to 1984 are based on fishing conducted with "J" hooks.

Year	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E	Total
1907	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	280
1910	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	271
1911	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	237
1912	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	176
1913	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	129
1914	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	124
1915	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	118
1916	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	137
1917	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	98
1918	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	96
1919	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	93
1920	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	96
1921	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	88
1922	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	73
1923	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	78
1924	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	74
1925	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	68
1926	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	67
1927	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65
1928	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	58
1929	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	51
1930	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	46
1931	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50
1932	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	60
1933	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	63
1934	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	62
1935	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	76
1936	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	71
1937	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	80
1938	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	88
1939	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	80
1940	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	81
1941	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	85
1942	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	90
1943	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
1944	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110
1945	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	102
1946	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	101
1947	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	99
1948	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	99
1949	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
1950	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
1950	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95

Table 5. Continued.

Year	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E	Total
1951	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	96
1952	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110
1953	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	131
1954	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	133
1955	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	119
1956	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	129
1957	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	110
1958	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	121
1959	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	129
1960	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	132
1961	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	127
1962	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	115
1963	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	105
1964	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	100
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	99
1966	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	100
1967	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	101
1968	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	103
1969	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	95
1970	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	91
1971	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	89
1972	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	78
1973	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	63
1974	59	64	57	65	57	NA	NA	NA	NA	NA	61
1975	59	68	53	66	68	NA	NA	NA	NA	NA	61
1976	33	53	42	60	65	NA	NA	NA	NA	NA	55
1977	83	61	45	61	73	NA	NA	NA	NA	NA	63
1978	39	63	56	78	53	NA	NA	NA	NA	NA	71
1979	50	48	80	86	37	NA	NA	NA	NA	NA	75
1980	37	65	79	118	113	NA	NA	NA	NA	NA	94
1981	33	67	144	142	160	158	99	110	NA	NA	111
1982	22	69	146	168	203	103	NA	91	NA	NA	127
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	63	147	284	502	474	366	161	NA	197	NA	291
1985	62	139	345	500	592	337	234	594	330	NA	351
1986	55	118	290	506	506	260	238	427	218	NA	315
1987	53	130	260	498	478	342	220	384	241	NA	316
1988	134	137	281	503	654	453	224	371	201	NA	363
1989	113	133	258	457	590	409	268	333	432	NA	353
1990	168	176	270	354	484	418	209	288	381	NA	315
1991	158	149	233	319	466	471	329	223	399	NA	314
1992	117	171	230	397	440	372	280	249	412	NA	315
1993	147	208	256	393	514	463	218	257	851	NA	369
1994	93	215	207	354	377	463	197	167	480	NA	302
1995	116	219	234	417	476	349	189	286	475	NA	326
1996	159	227	239	473	557	515	269	297	543	NA	387
1997	226	241	246	458	563	483	275	335	671	NA	400
1998	194	232	236	452	611	525	287	287	627	NA	403
1999	342	213	199	437	538	497	310	271	535	NA	390
2000	263	229	187	443	579	548	320	223	556	NA	399

Table 5. Continued.

Year	2A	2B	2C	3A	3B	4A	4B	4C	4D	4E	Total
2001	171	227	196	469	431	474	270	203	511	NA	358
2002	181	223	244	508	399	402	245	148	503	NA	356
2003	173	221	233	485	365	355	196	105	388	NA	325
2004	143	203	240	486	328	315	202	120	445	NA	315
2005	137	195	203	446	293	301	238	91	379	NA	293
2006	156	201	170	403	292	241	218	72	280	NA	267
2007	96	198	160	398	257	206	230	65	237	NA	249
2008	69	174	161	370	234	206	193	94	247	NA	229
2009	98	188	155	318	211	234	189	88	249	NA	220
2010	149	222	158	285	173	182	142	82	188	NA	202
2011	92	240	175	280	140	189	165	75	166	NA	196
2012	102	248	207	263	133	194	149	60	155	108	193
2013	110	246	195	238	112	160	127	56	157	NA	178
2014	106	282	204	234	100	136	146	60	196	NA	183
2015	110	291	212	274	144	156	149	98	164	NA	202
2016	59	317	227	277	155	169	113	72	177	NA	203

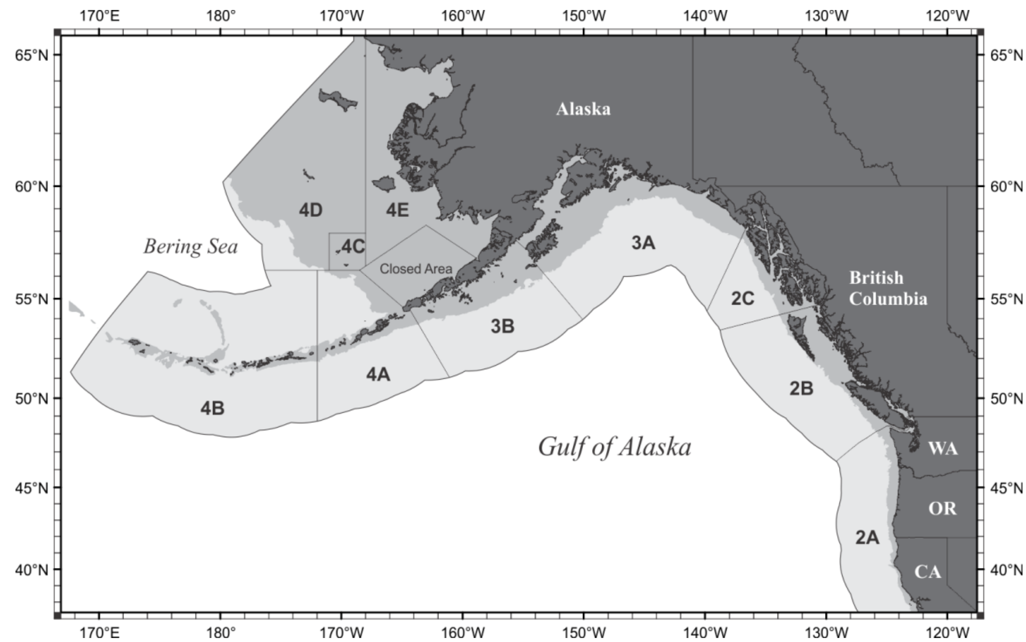


Figure 1. The IPHC's regulatory areas. Shaded region indicates the Exclusive Economic Zone (EEZ) of the United States and Canada.

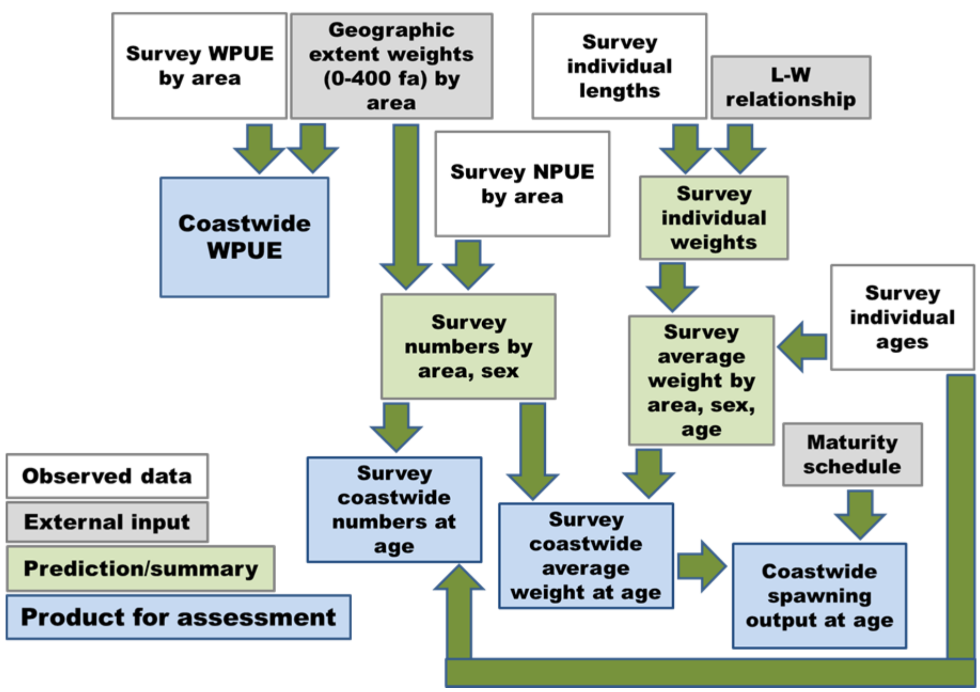


Figure 2. General schematic of the processing of the setline survey data.

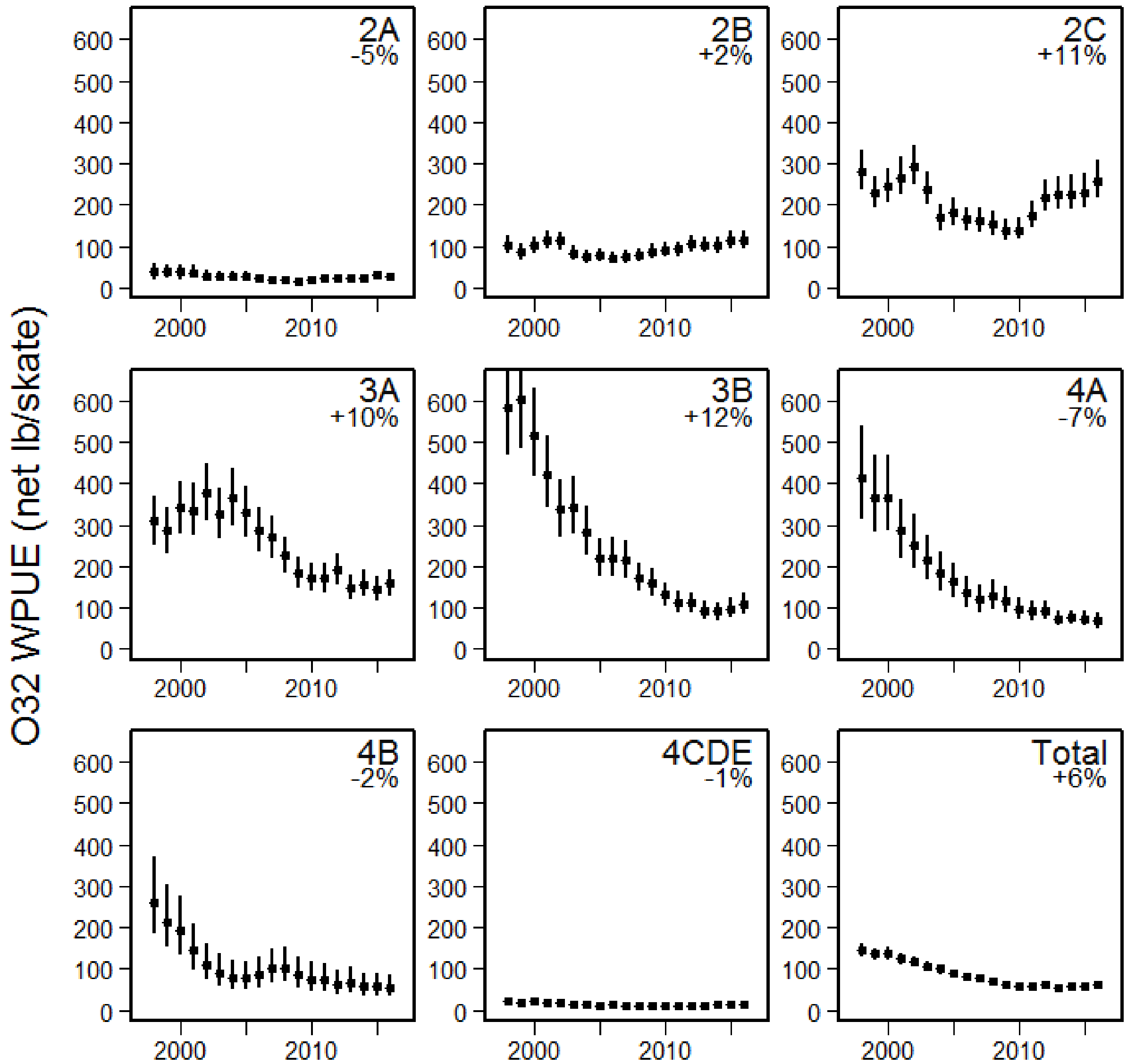


Figure 3. Recent setline survey O32 WPUE (lbs/skate) by regulatory area for 1998-2016. Percentages for each area indicate the change from 2015 to 2016.

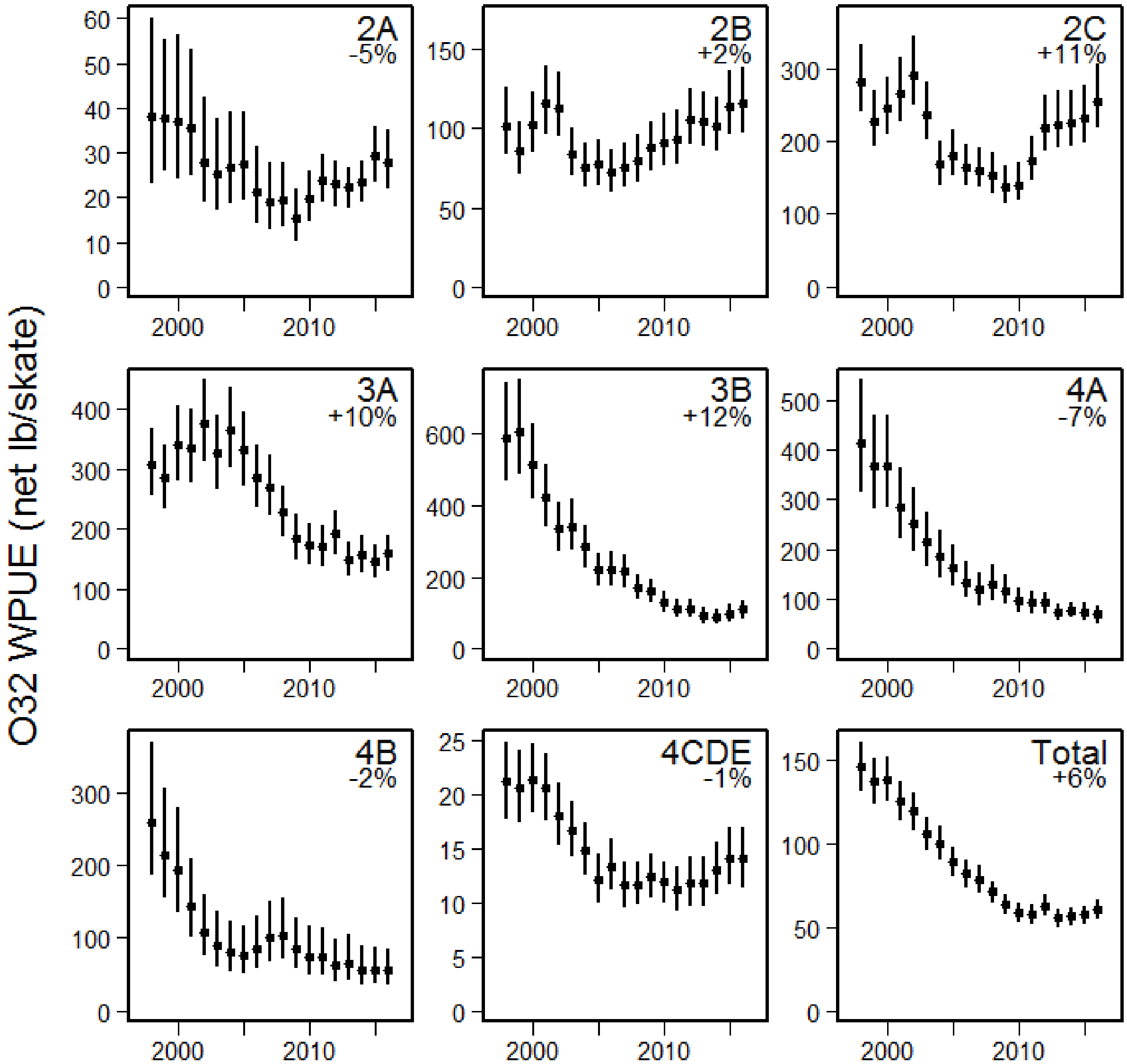


Figure 4. Recent setline survey O32 WPUE (lbs/skate) by regulatory area for 1998-2016. Percentages for each area indicate the change from 2015 to 2016. Note that unlike the previous figure, the y-axes differ between panels.

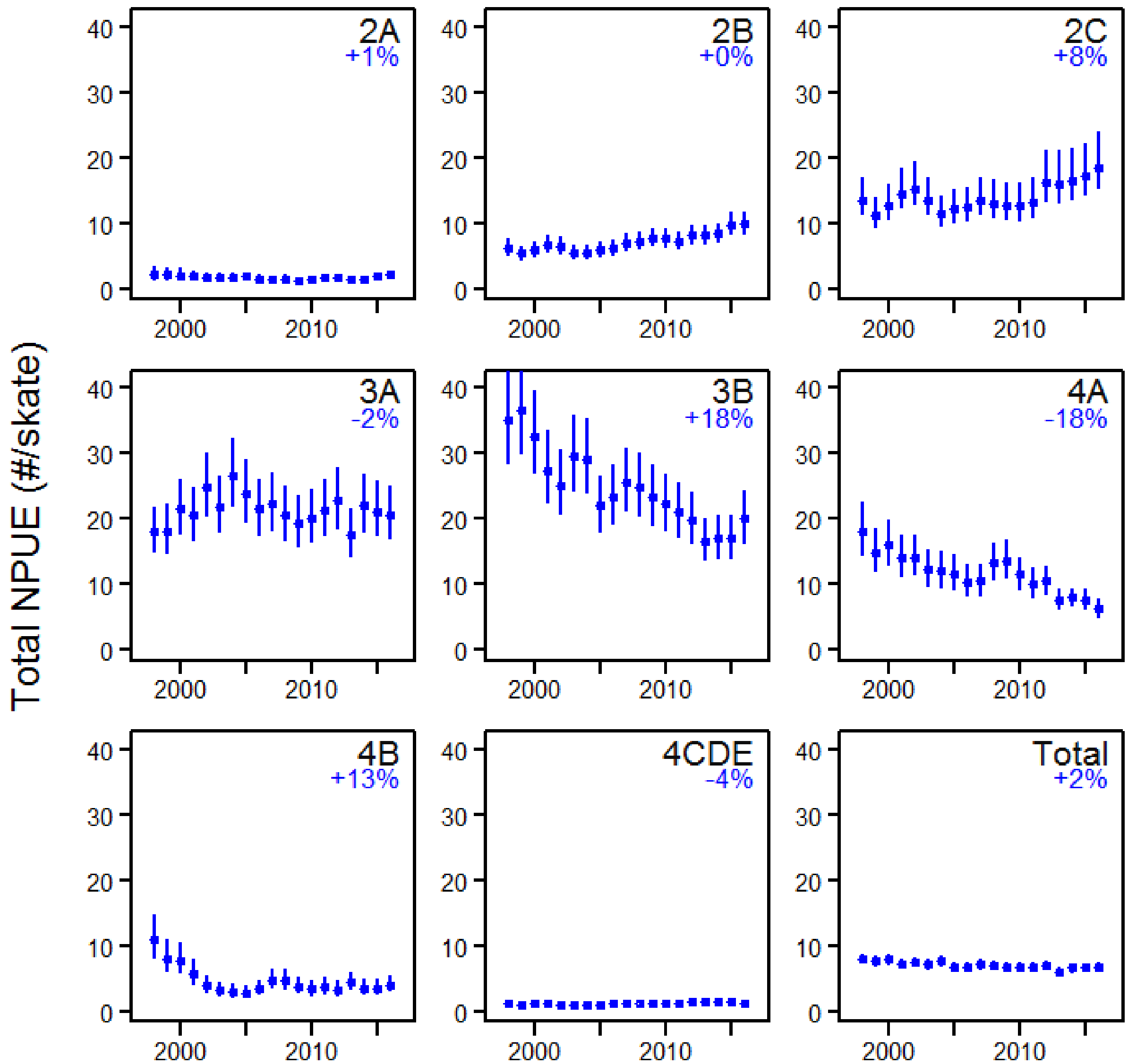


Figure 5. Recent setline survey NPUE (fish/skate) for all sizes of fish by regulatory area for 1998-2016. Percentages for each area indicate the change from 2015 to 2016.

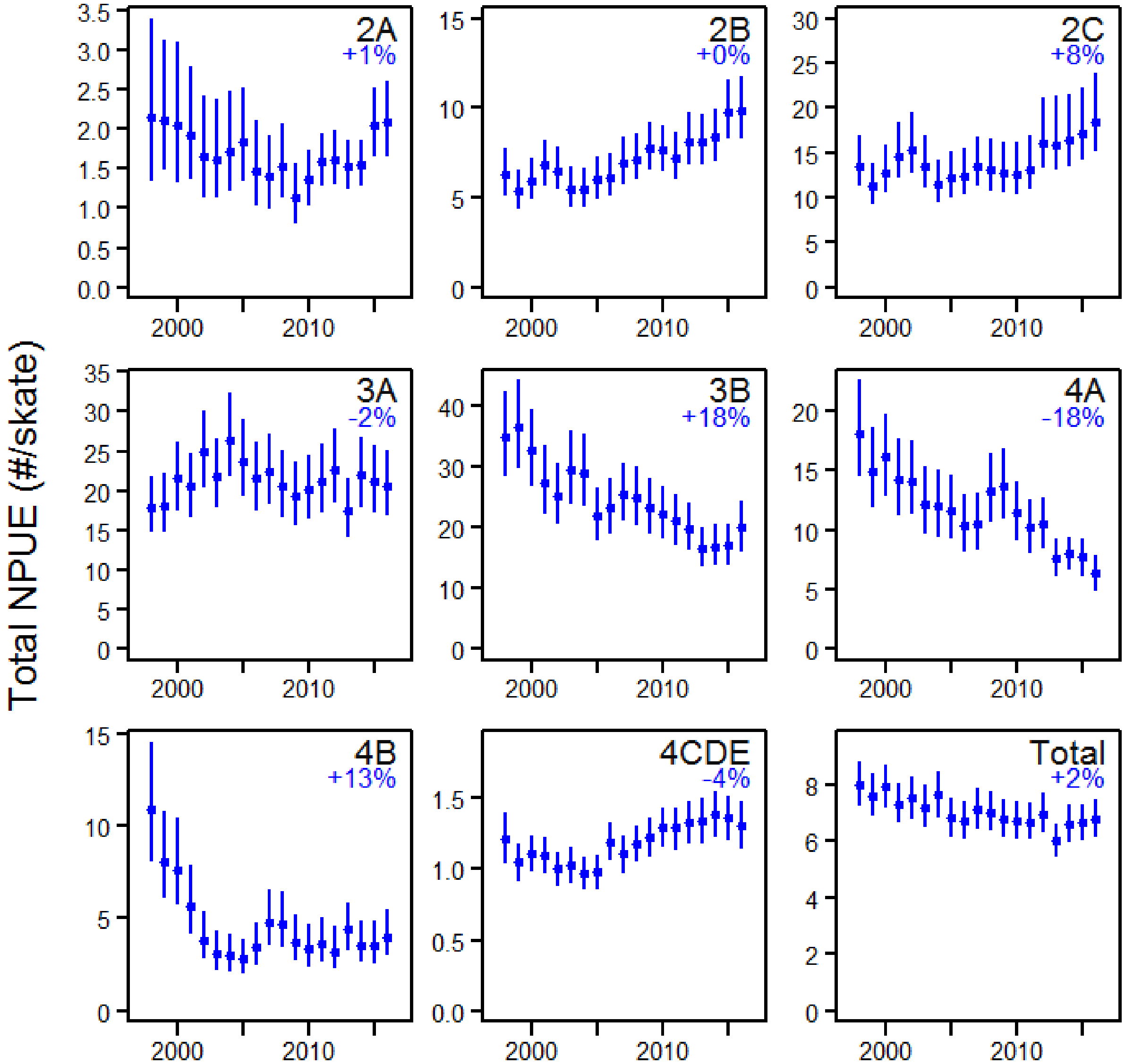


Figure 6. Recent setline survey NPUE (fish/skate) for all sizes of fish by regulatory area for 1998-2016. Percentages for each area indicate the change from 2015 to 2016. Note that unlike the previous figure, the y-axes differ between panels.

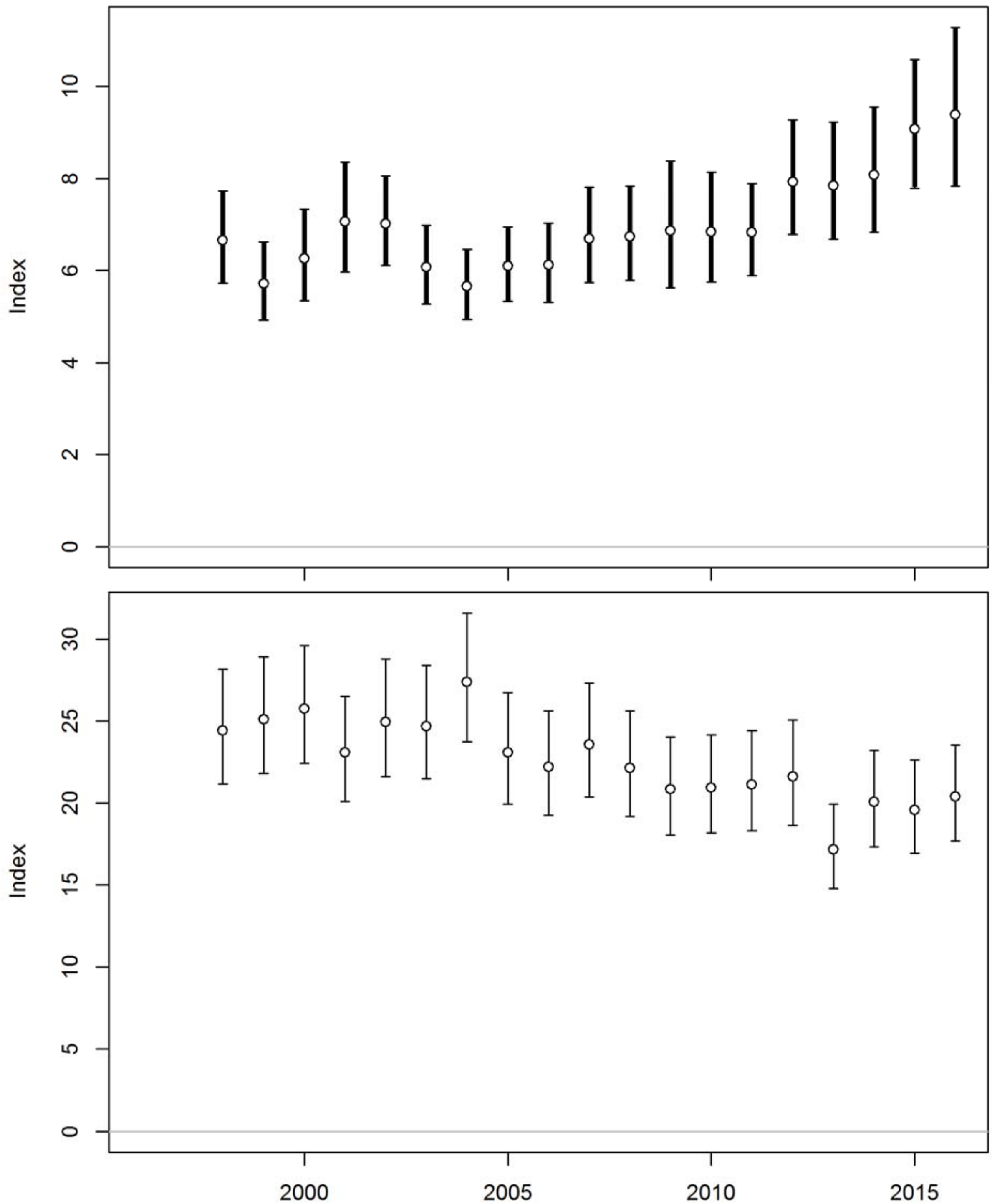


Figure 7. Recent aggregate setline survey total NPUE by geographic region (Area 2, upper panel; Area 3, lower panel).

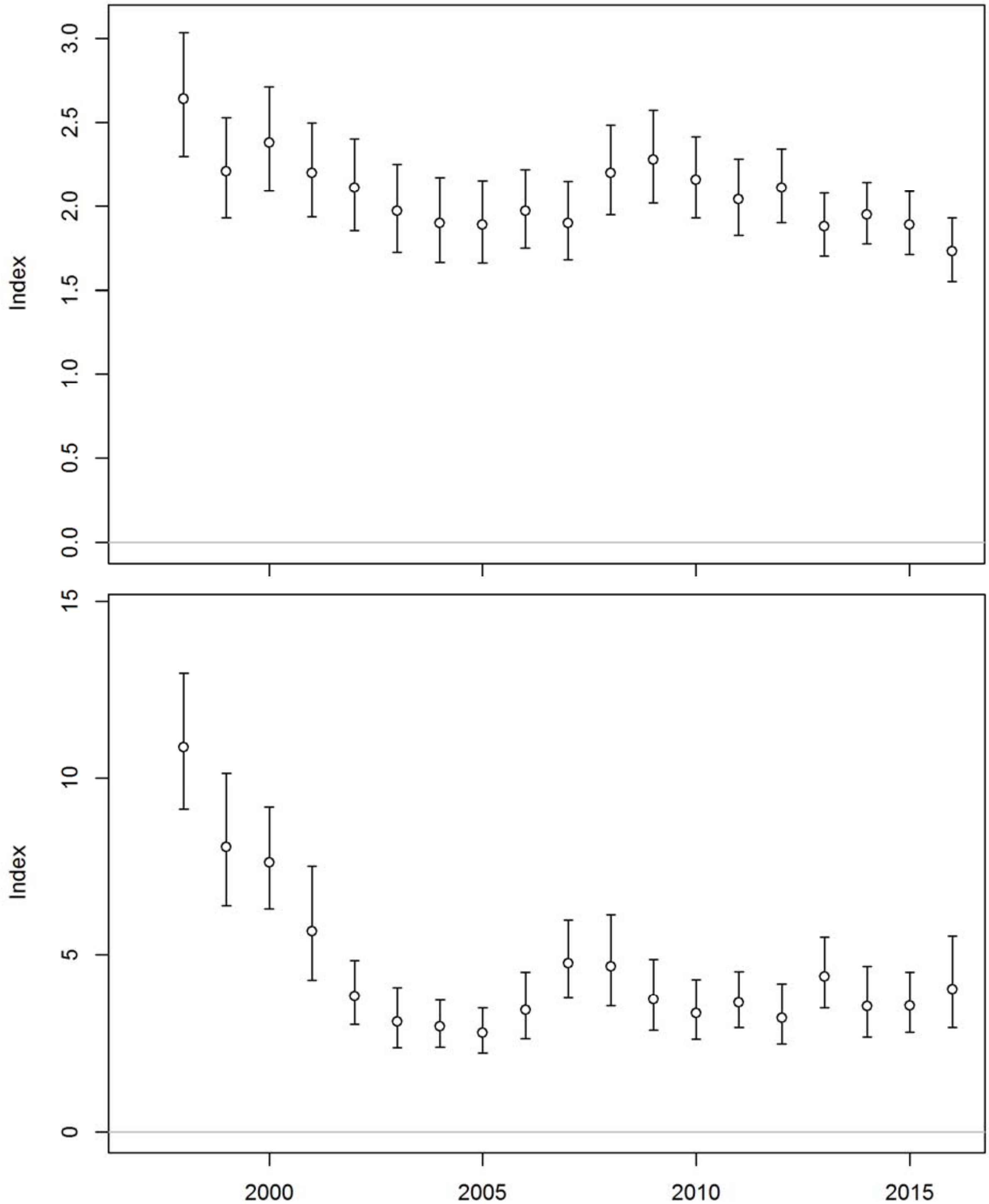


Figure 8. Recent aggregate setline survey total NPUE by geographic region (Area 4, upper panel; Area 4B, lower panel).

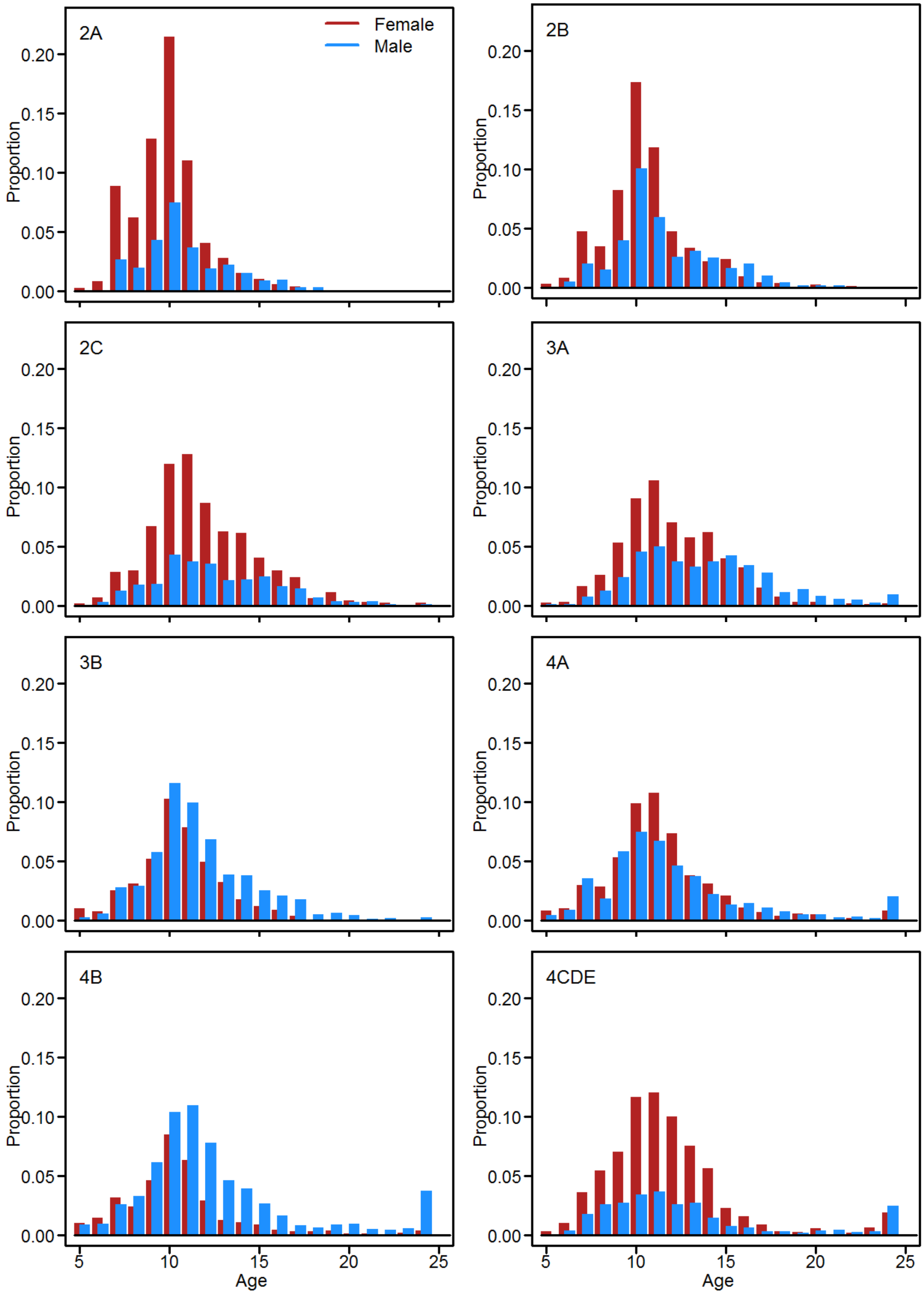


Figure 9. Age distributions from the 2016 setline survey by regulatory area.

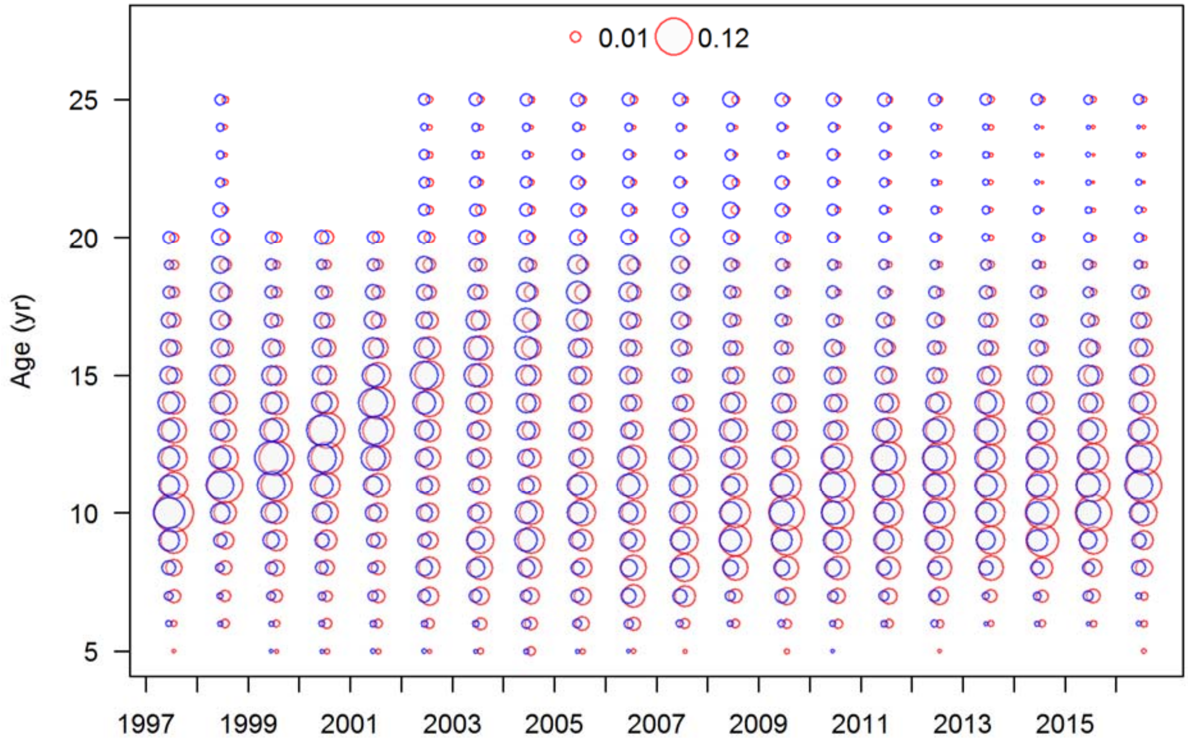


Figure 10. Recent coastwide proportions-at-age for females (red circles) and males (blue circles) from the setline survey. Proportions sum to 1.0 across both sexes within each year.

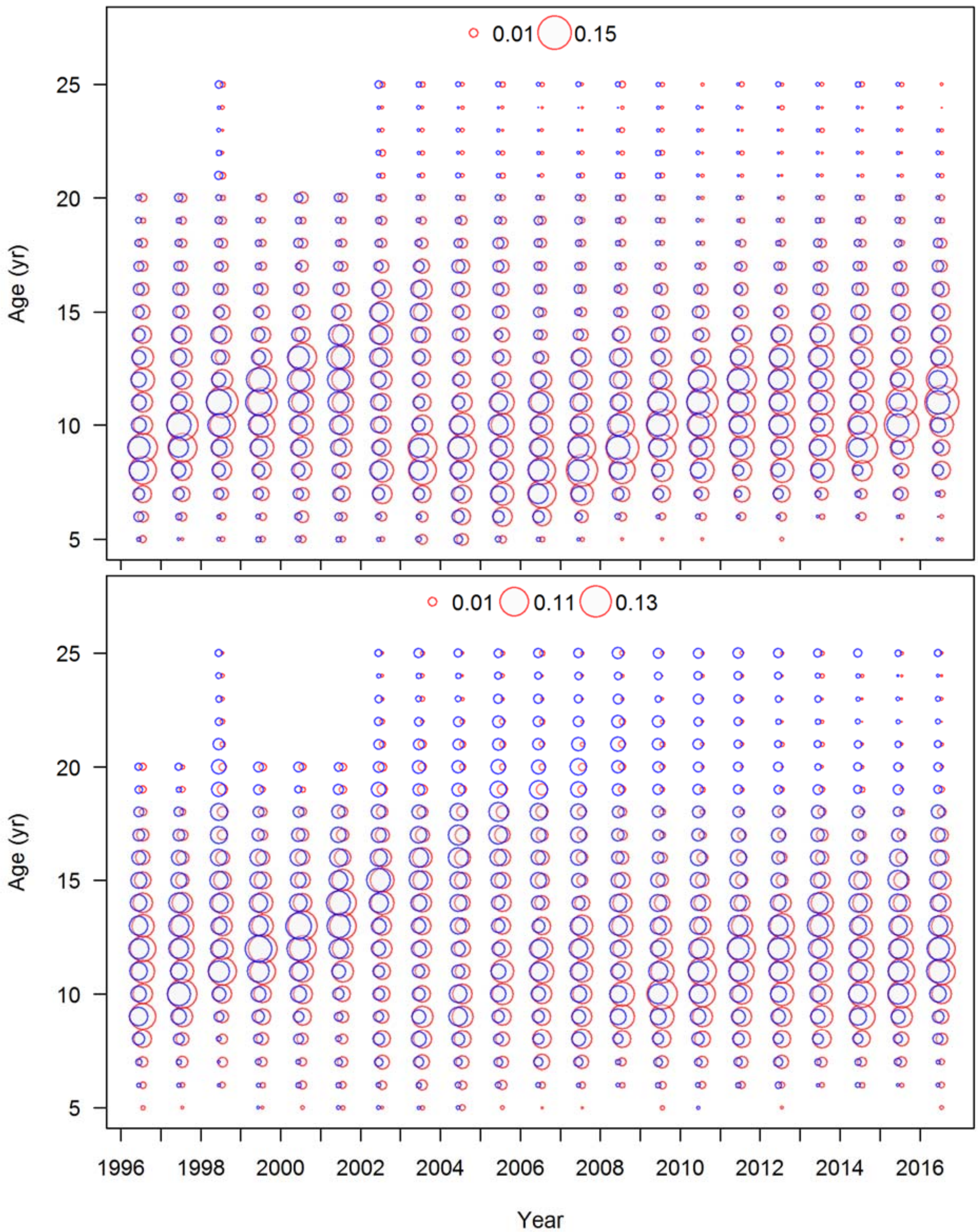


Figure 11. Recent proportions-at-age for female (red circles) and male (blue circles) Pacific halibut captured by the setline survey by geographic region: Area 2 (upper panel), Area 3 (lower panel). Proportions sum to 1.0 across both sexes within each year.

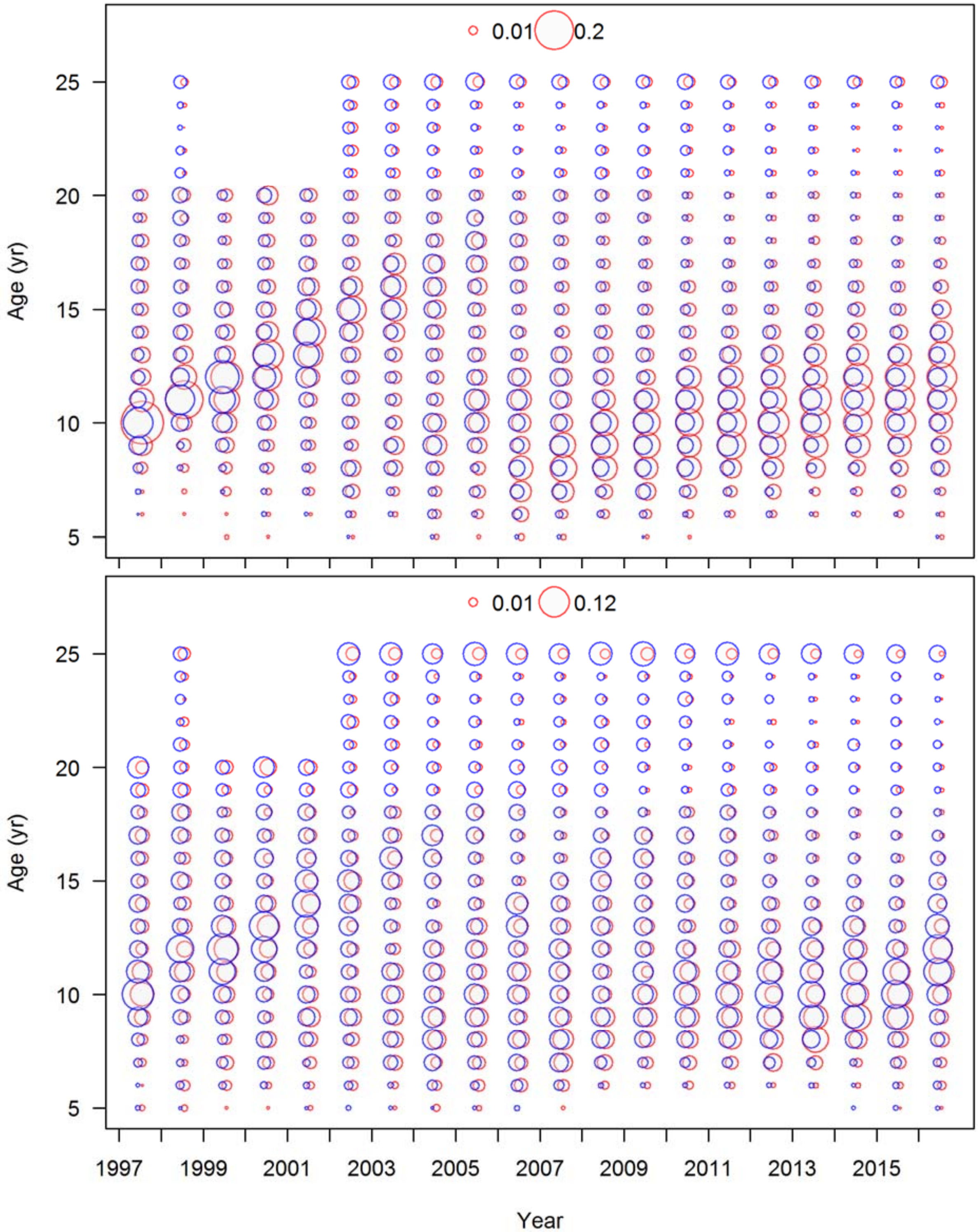


Figure 12. Recent proportions-at-age for female (red circles) and male (blue circles) Pacific halibut captured by the setline survey by geographic region: Area 4 (upper panel) and Area 4B (lower panel) Pacific halibut captured by the setline survey. Proportions sum to 1.0 across both sexes within each year.

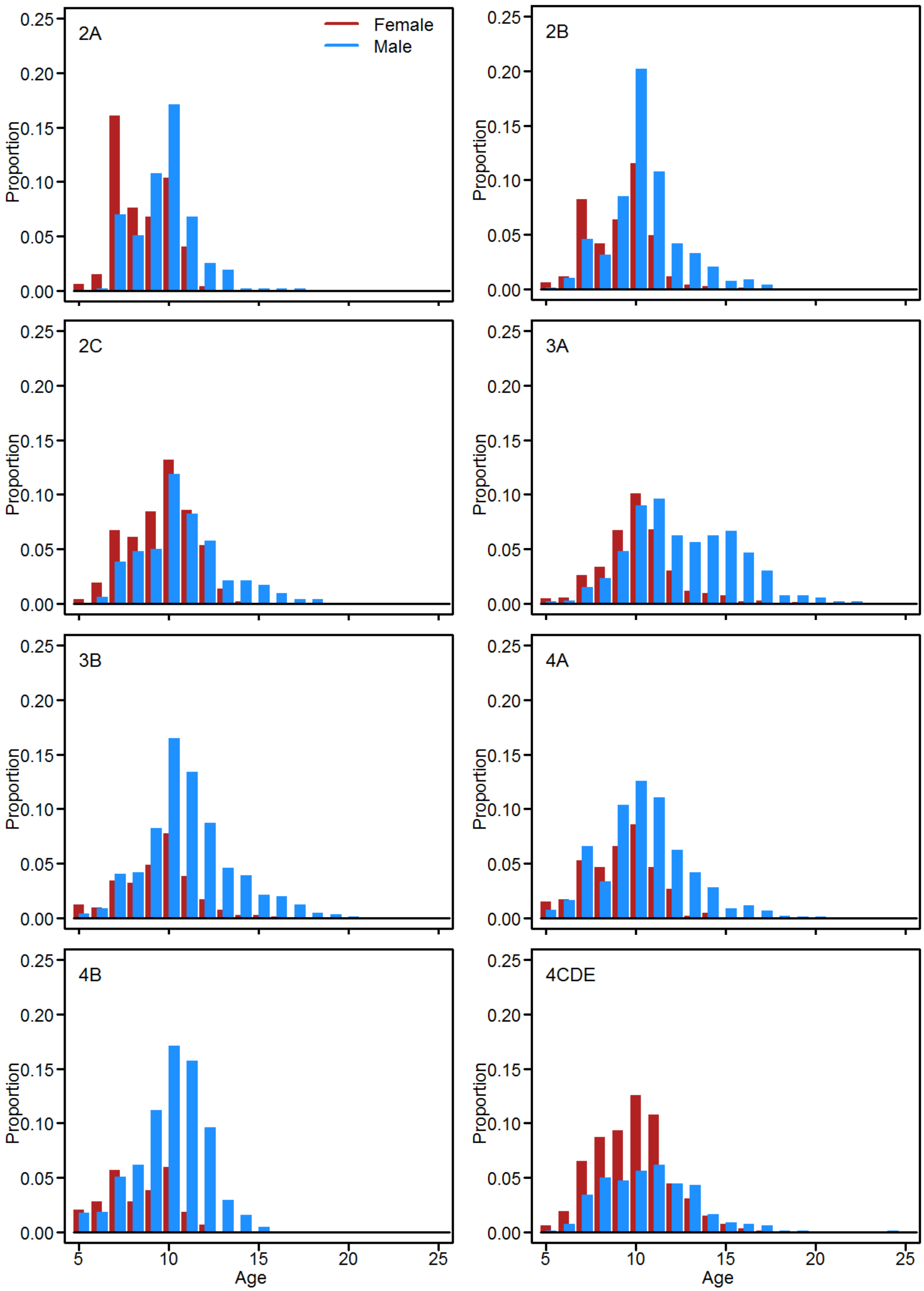


Figure 13. Sub-legal age distributions from the 2015 setline survey by regulatory area.

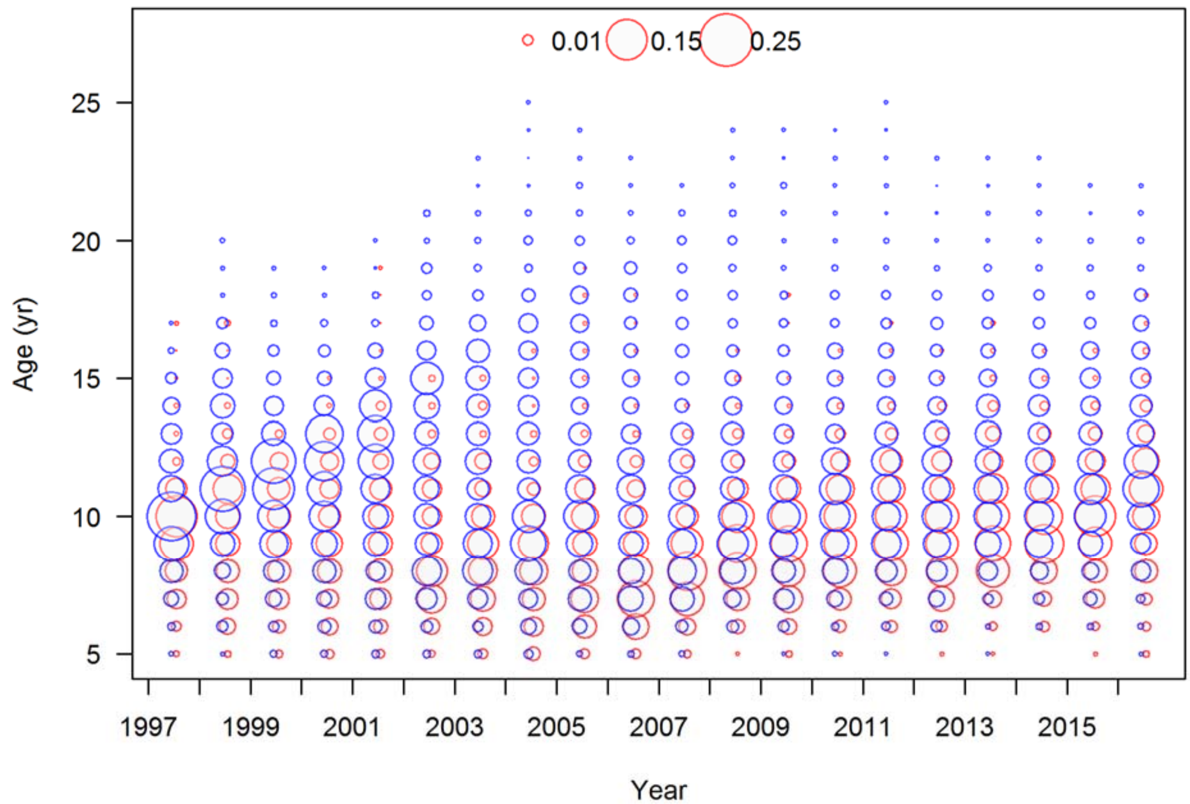


Figure 14. Recent coastwide proportions-at-age for sublegal females (red circles) and males (blue circles) from the setline survey. Proportions sum to 1.0 across both sexes within each year.

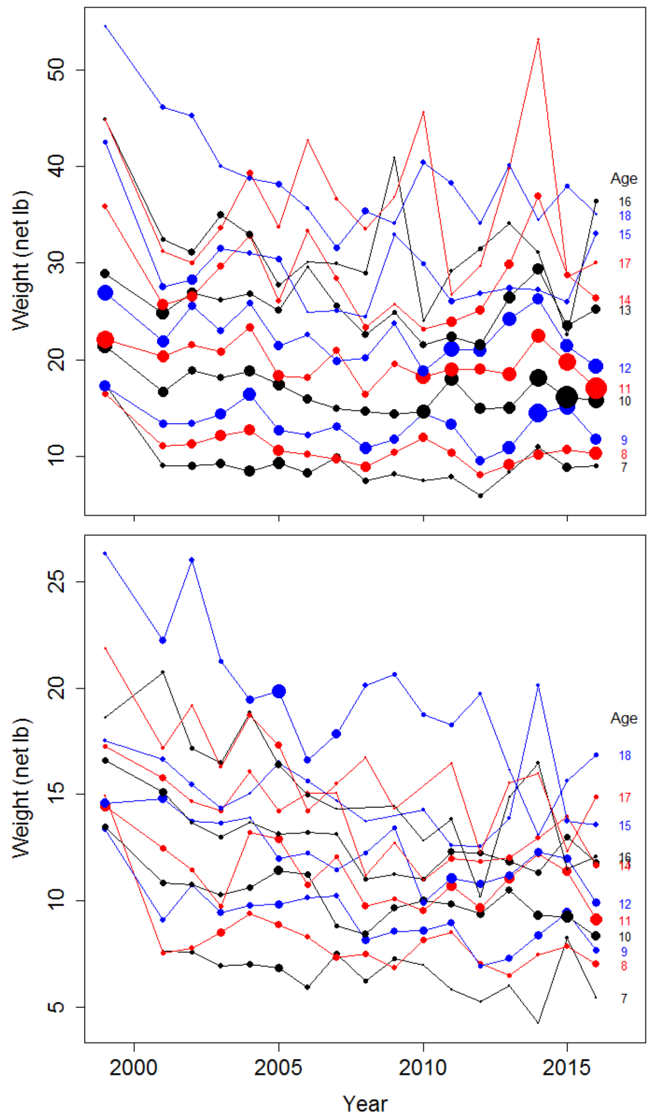


Figure 15. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 2A captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

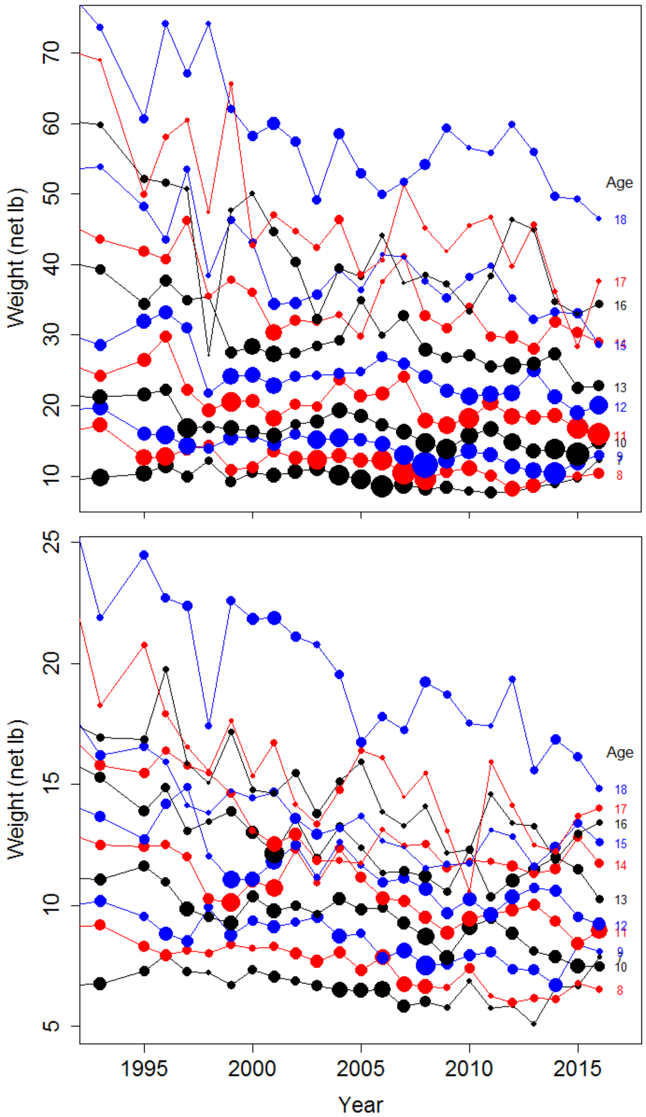


Figure 16. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 2B captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

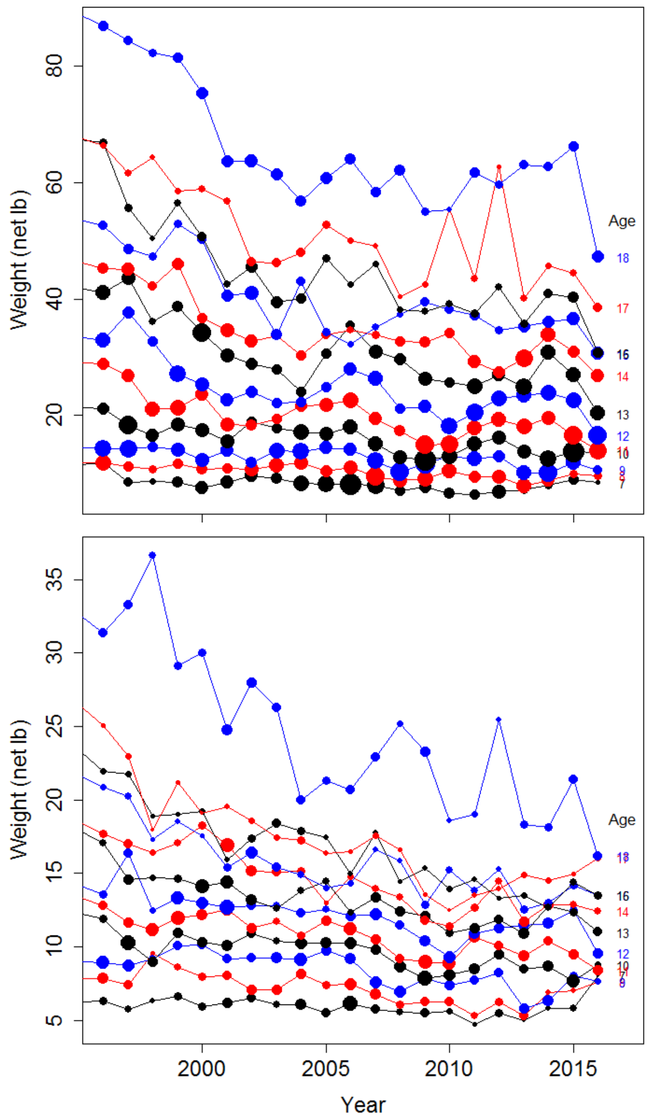


Figure 17. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 2C captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

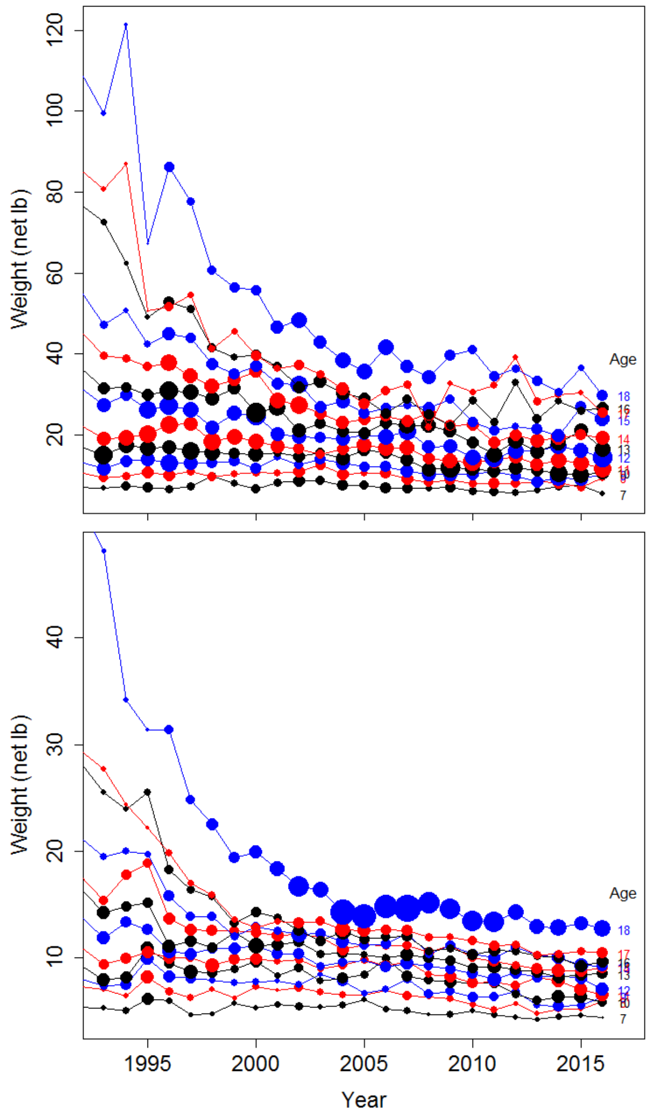


Figure 18. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 3A captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

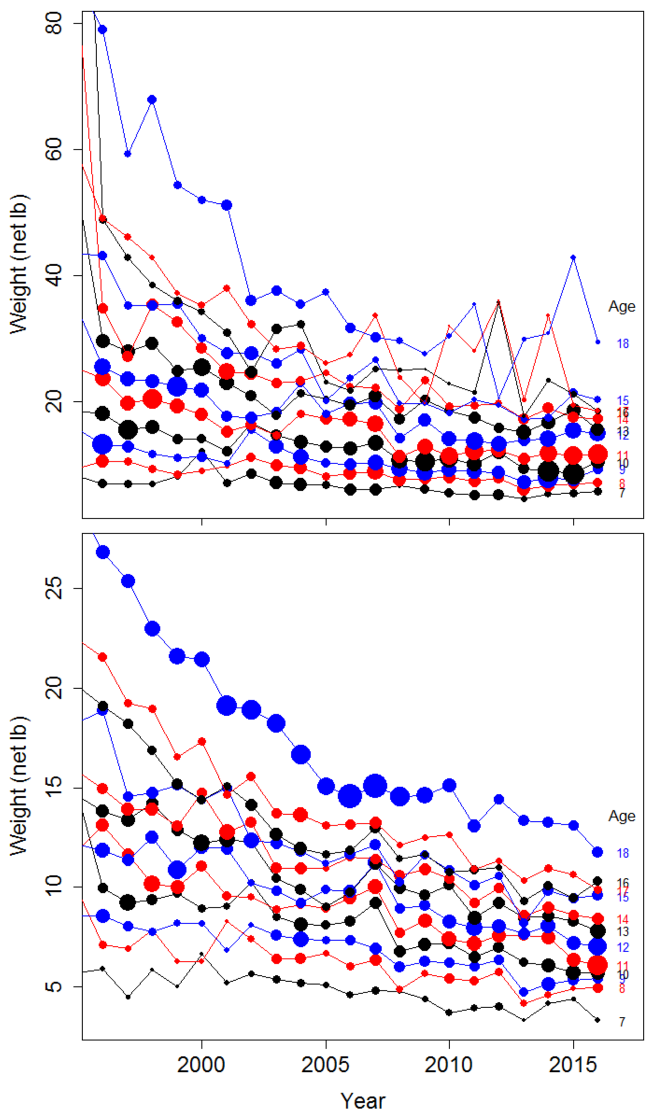


Figure 19. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 3B captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

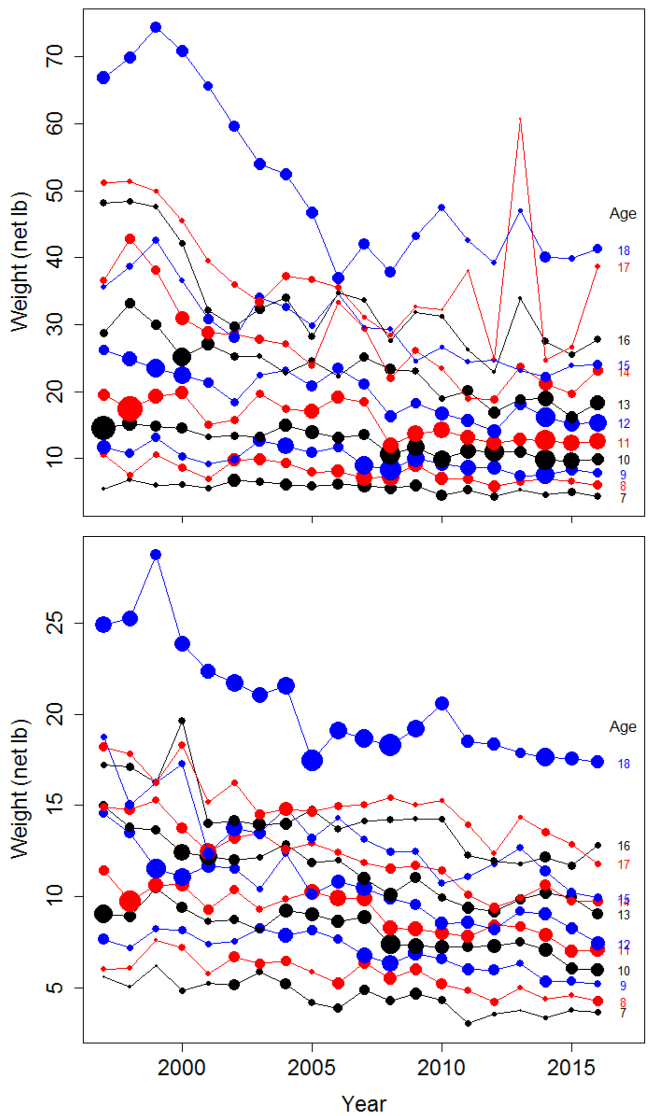


Figure 20. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 4A captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

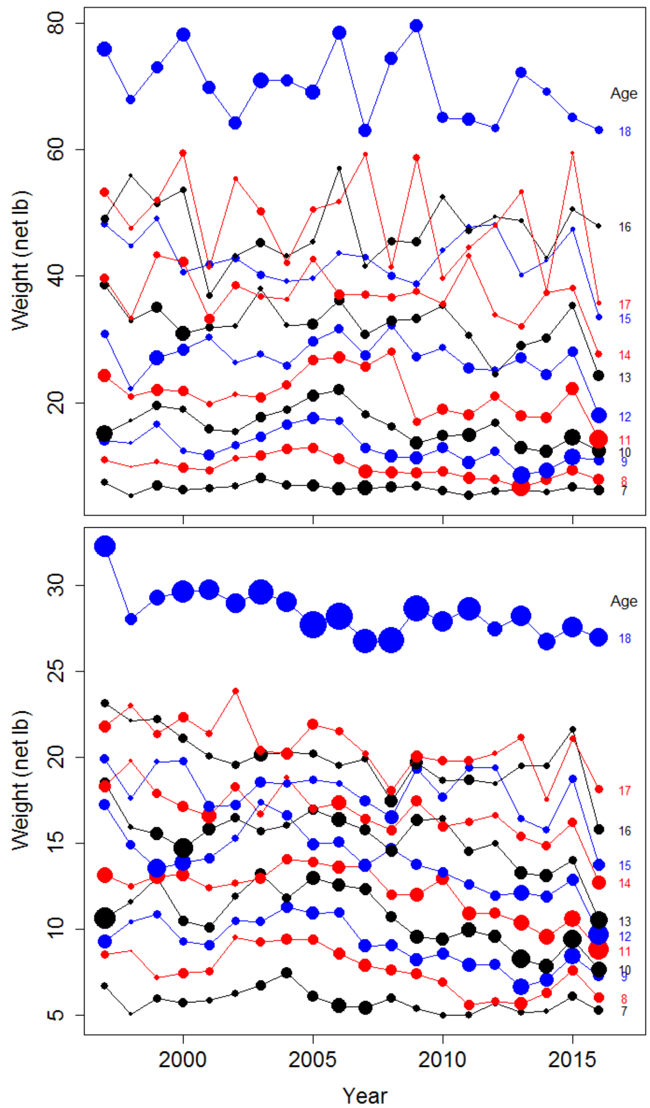


Figure 21. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 4B captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

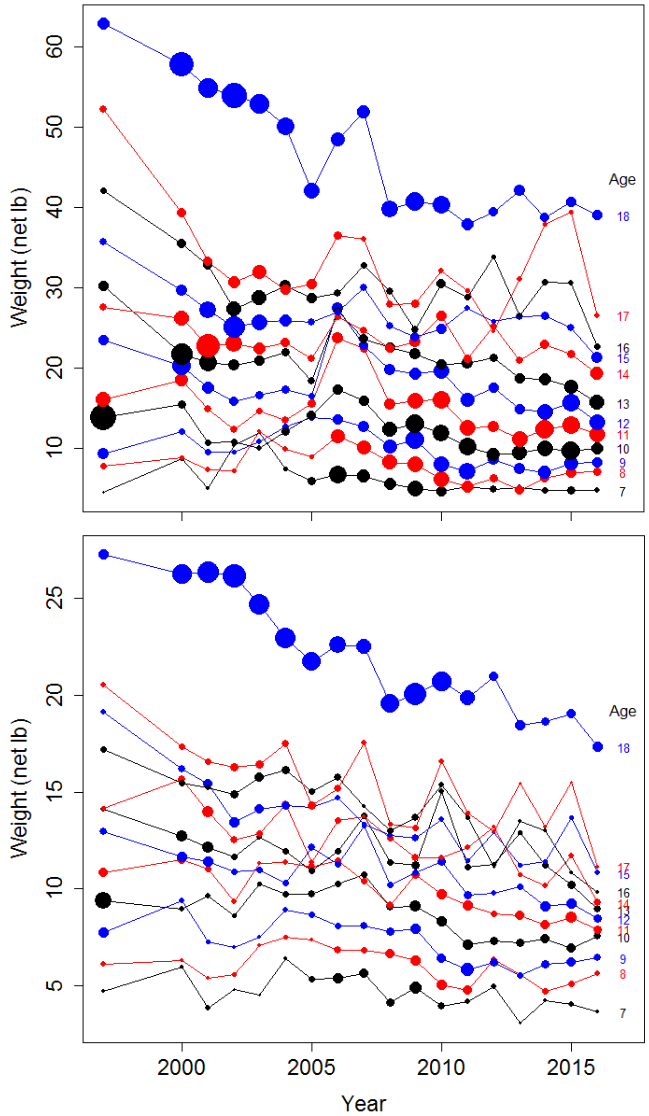


Figure 22. Trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from regulatory Area 4CDE captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

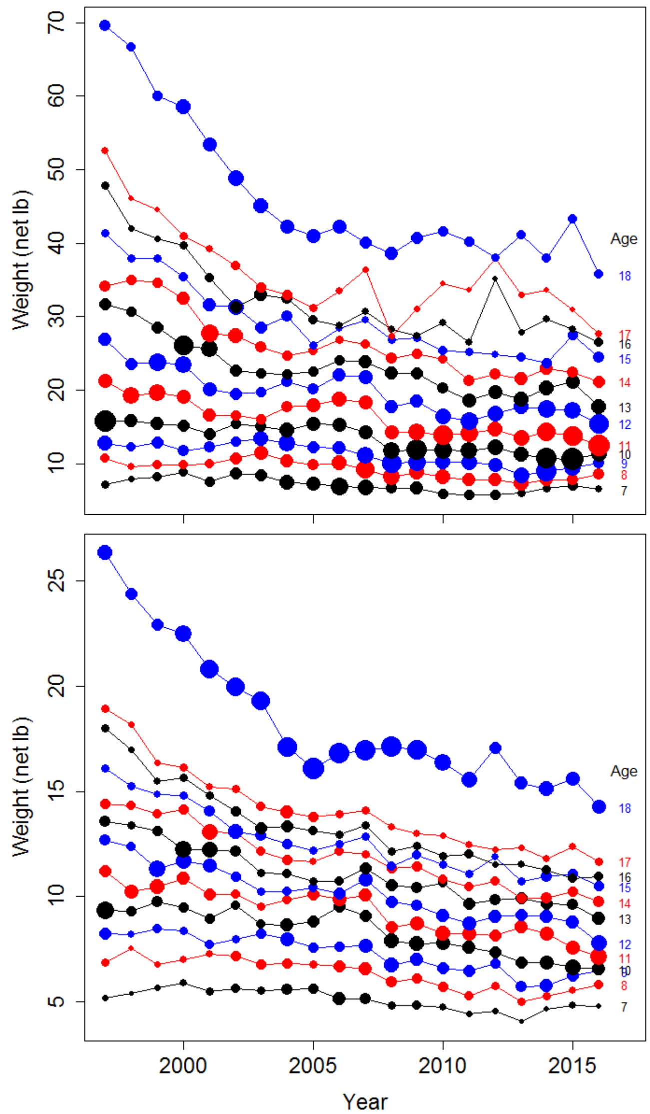


Figure 23. Weighted coastwide trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from all regulatory areas captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated for clarity.

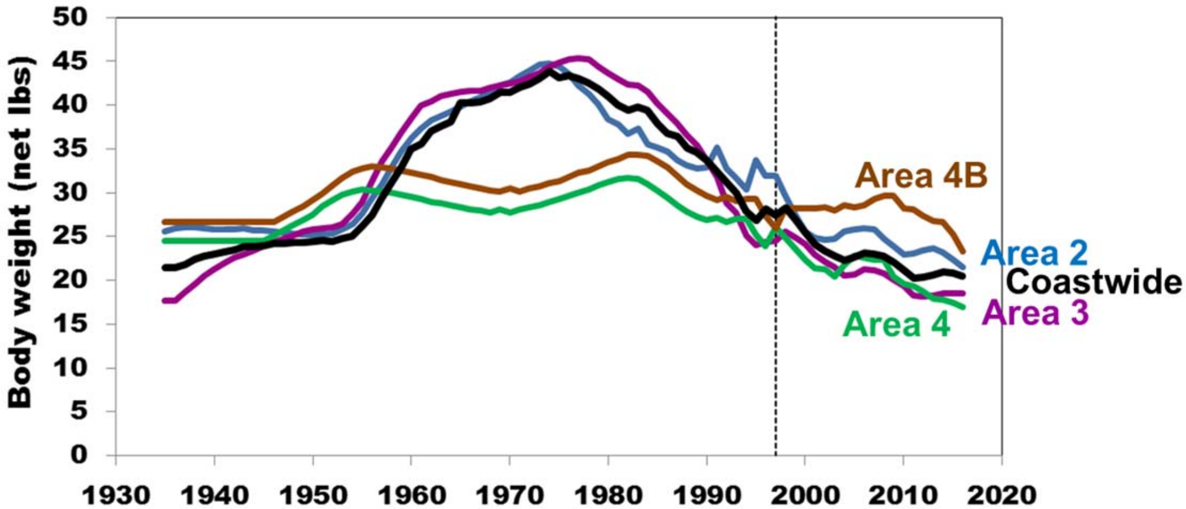


Figure 24. Coastwide and region-specific estimated female average weight-at-age 12 trends from setline survey and fishery data since 1935.

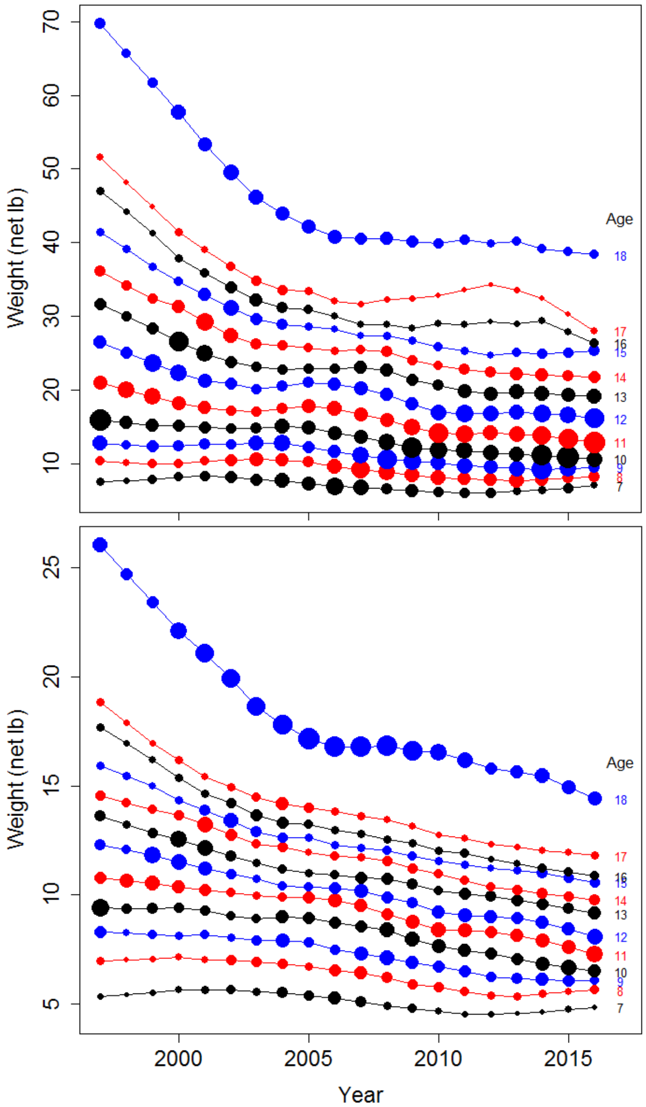


Figure 25. Weighted and smoothed recent coastwide trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from all regulatory areas captured by the setline survey. The size (area) of the points is proportional to the number of fish contributing to each observation; ages 18 and greater have been aggregated.

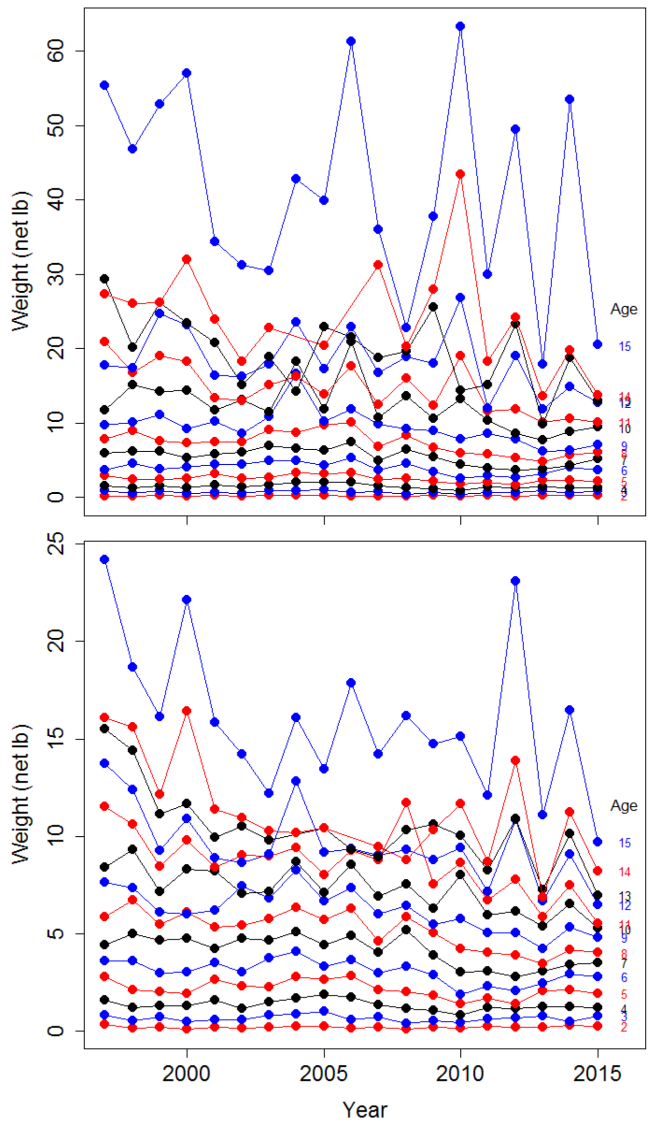


Figure 26. Raw trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from the NMFS Bering Sea trawl survey. Ages 15 and greater have been aggregated.

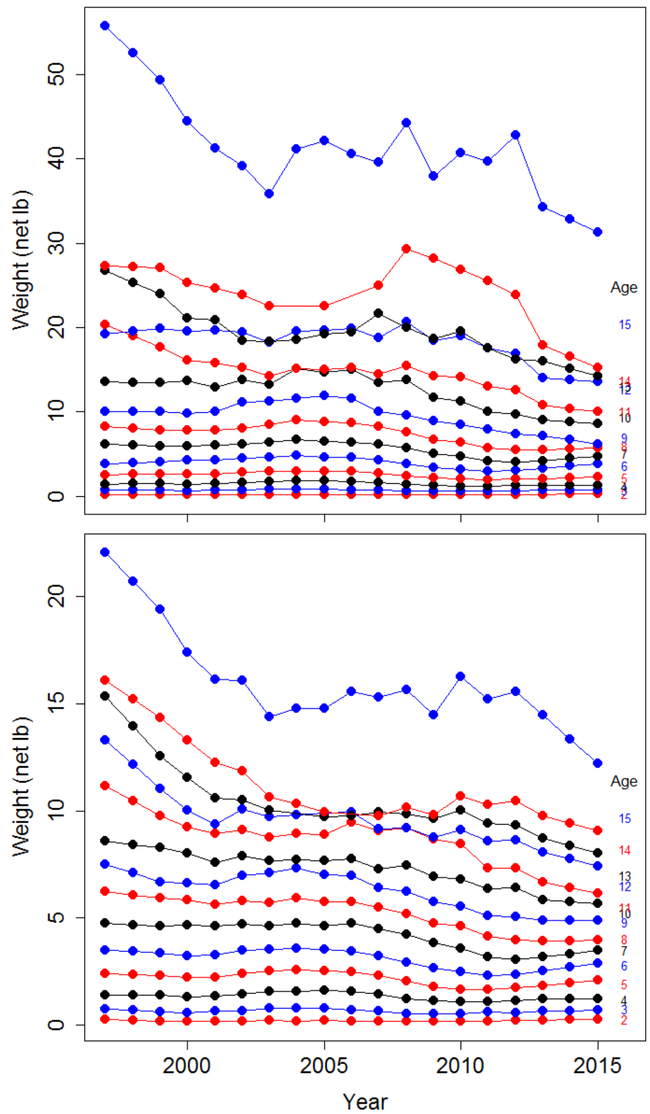


Figure 27. Smoothed trends in weight-at-age for female (upper panel), and male (lower panel) Pacific halibut from the NMFS Bering Sea trawl survey. Ages 15 and greater have been aggregated.

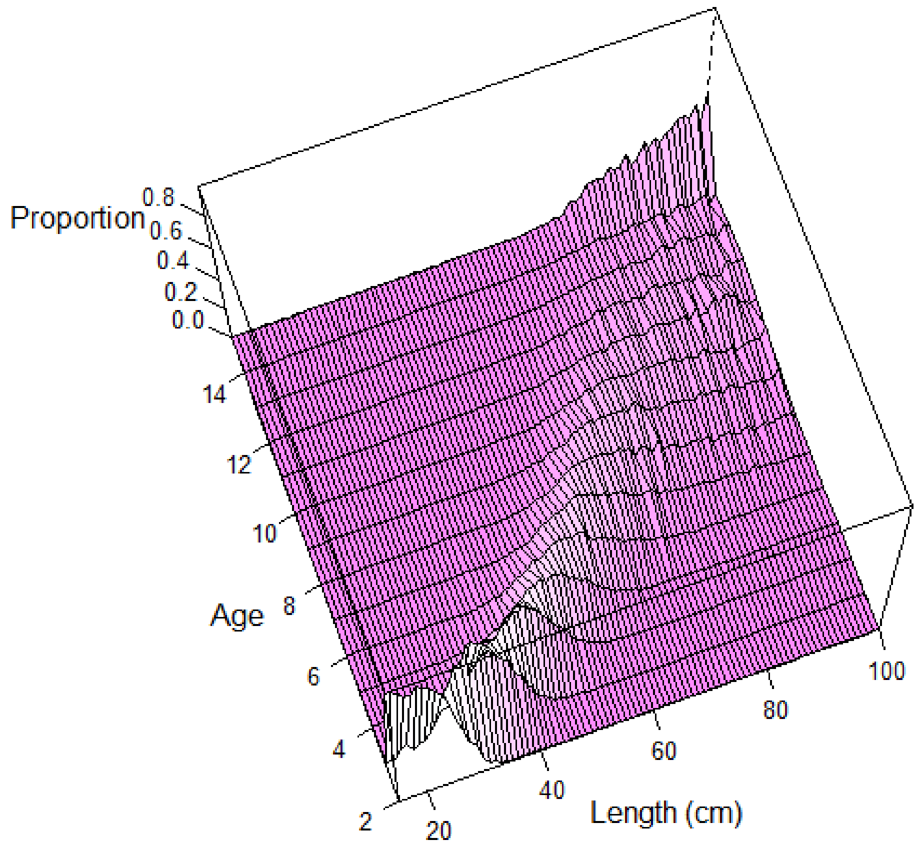


Figure 28. Global age-length key created from NMFS trawl surveys in Alaska. Proportions-at-age that sum to 1.0 within each length.

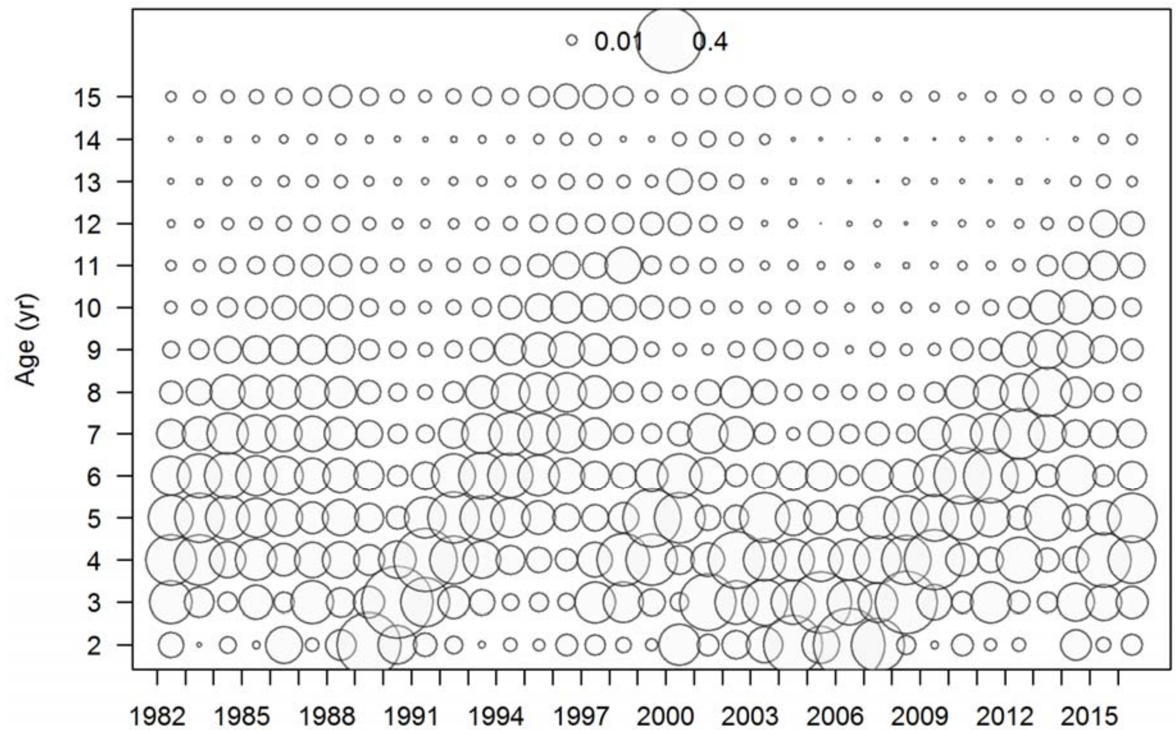


Figure 29. Proportions-at-age from the NMFS Bering Sea trawl survey. Ages 15 and greater have been aggregated; proportions sum to 1.0 within each year.

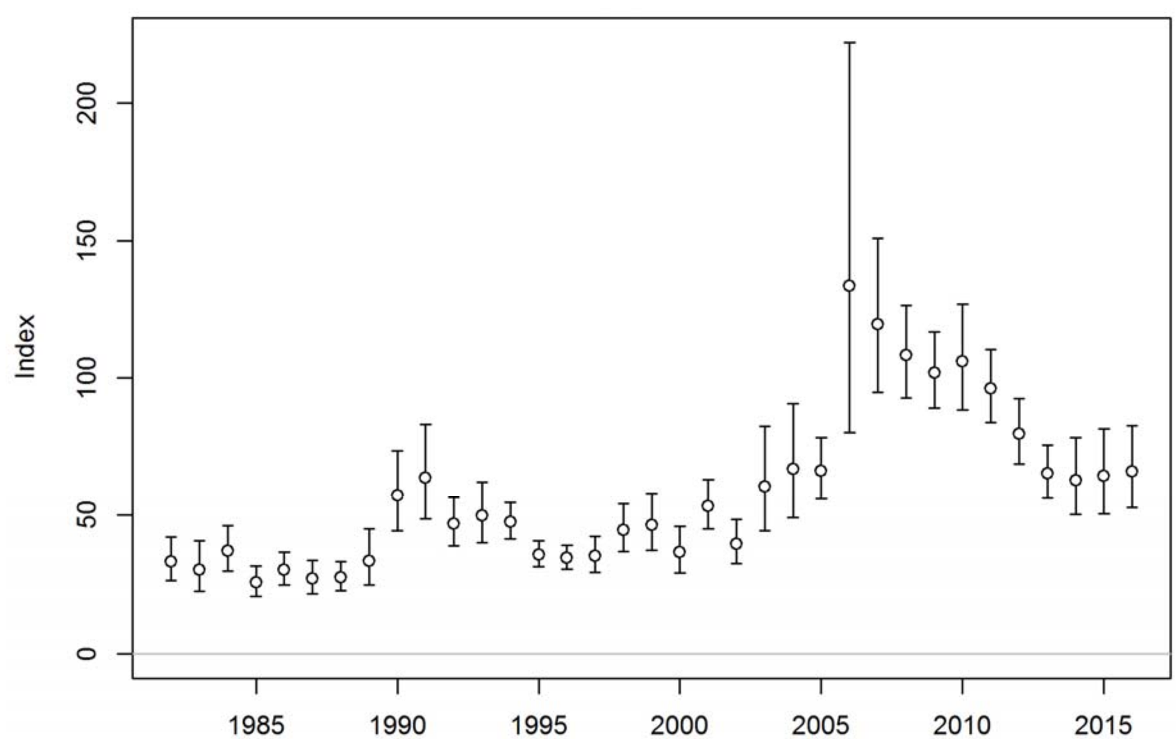


Figure 30. Index of abundance (millions of fish) of Pacific halibut from the NMFS Bering Sea trawl survey.

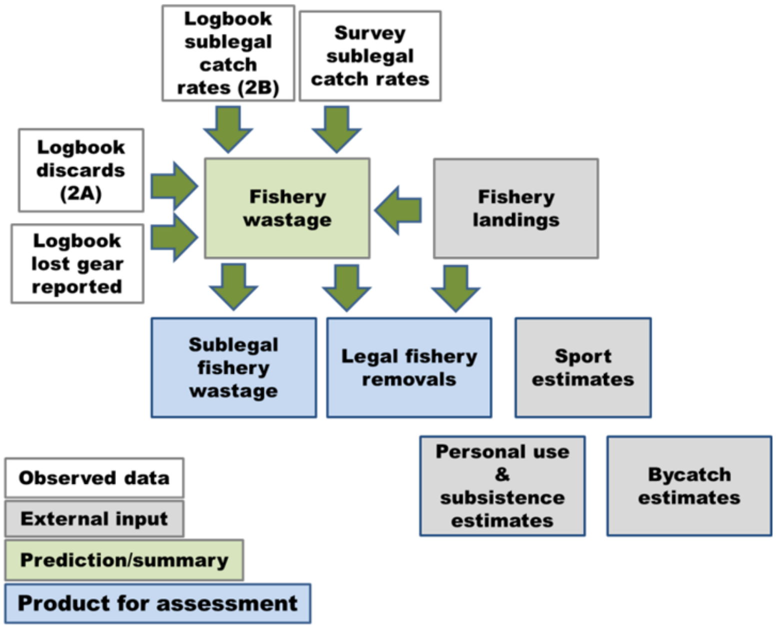


Figure 31. Relationships among estimates Pacific halibut mortality by source.

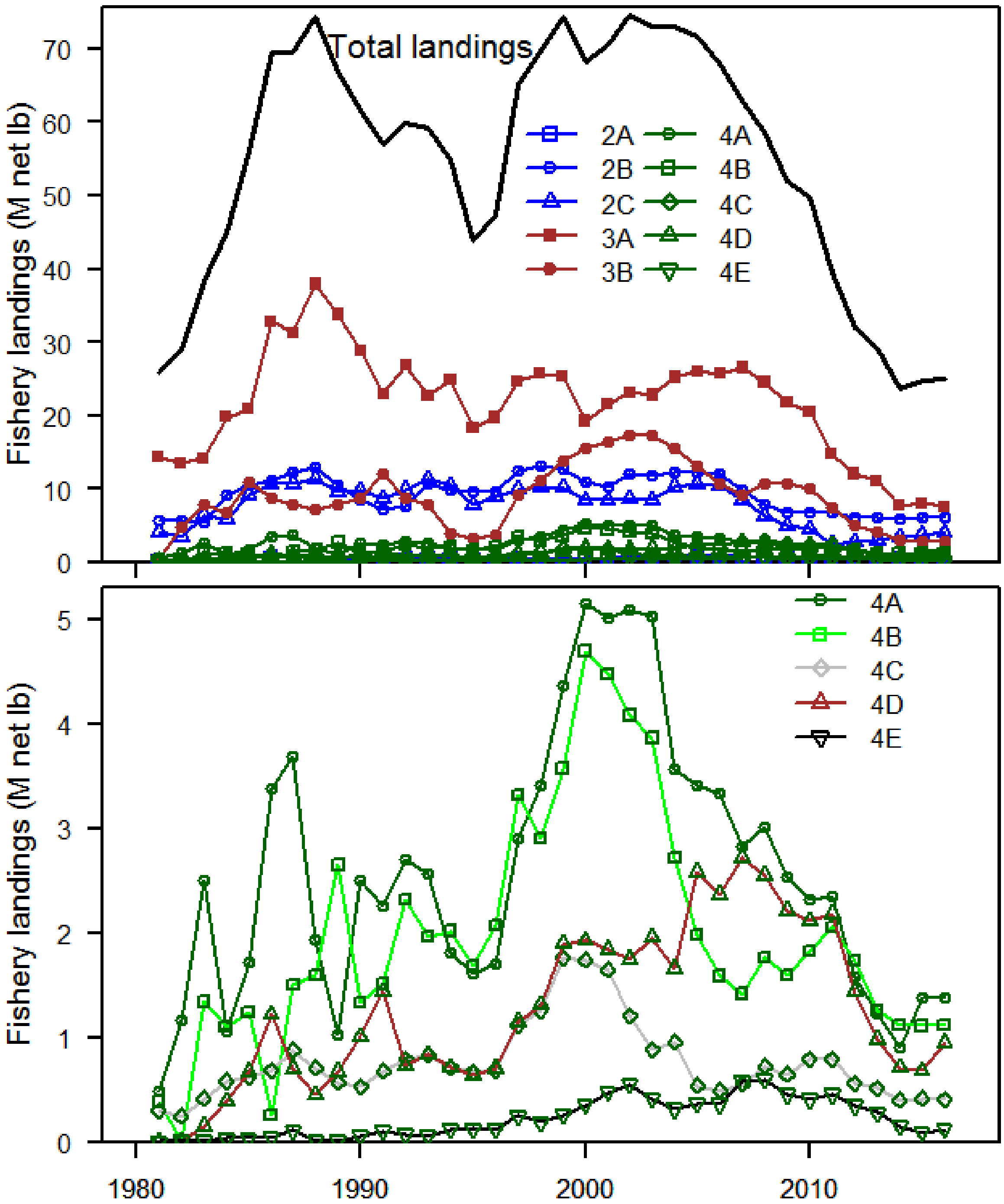


Figure 32. Recent landings of Pacific halibut by the directed commercial fishery by regulatory area (upper panel), and within Areas 4A to 4E for better resolution of the trends (lower panel).

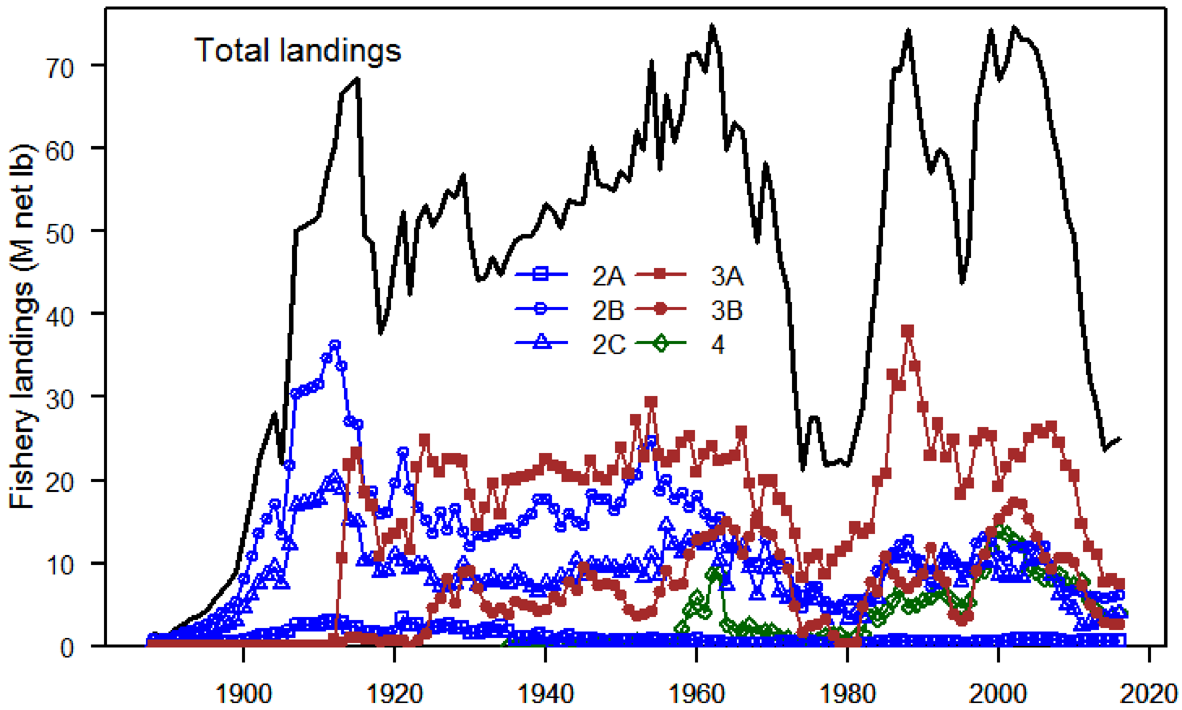


Figure 33. Landings of Pacific halibut by the directed commercial fishery by regulatory area.

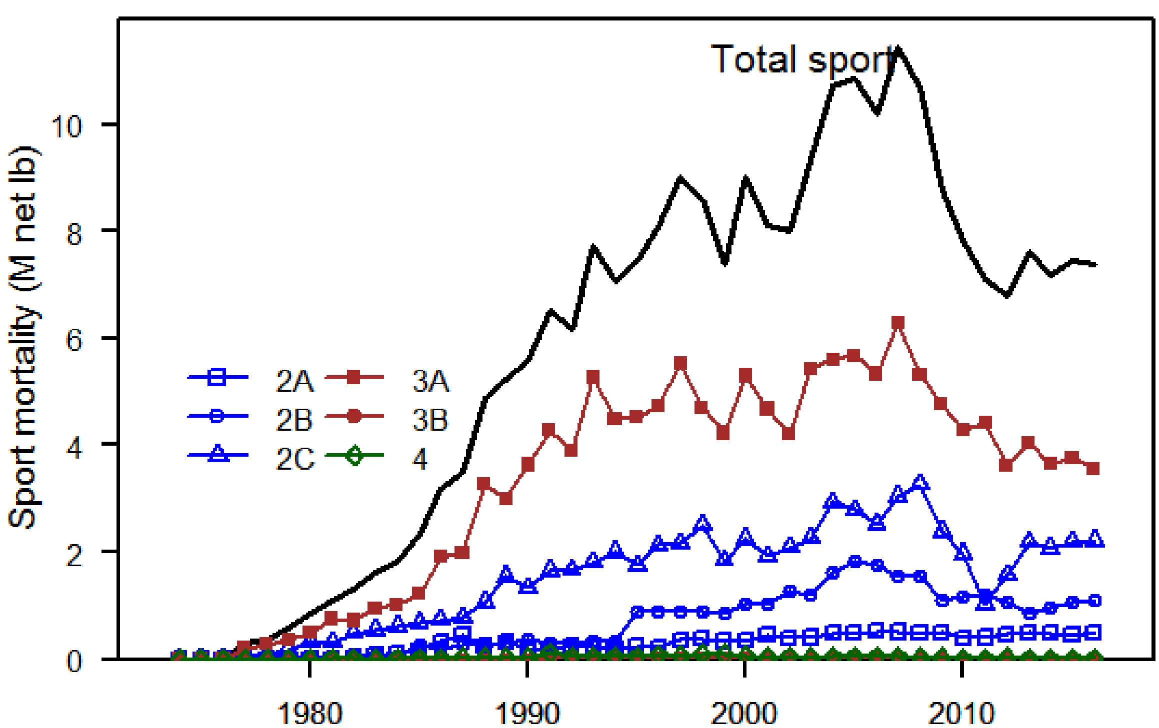


Figure 34. Sport (recreational) removals of Pacific halibut by regulatory area.

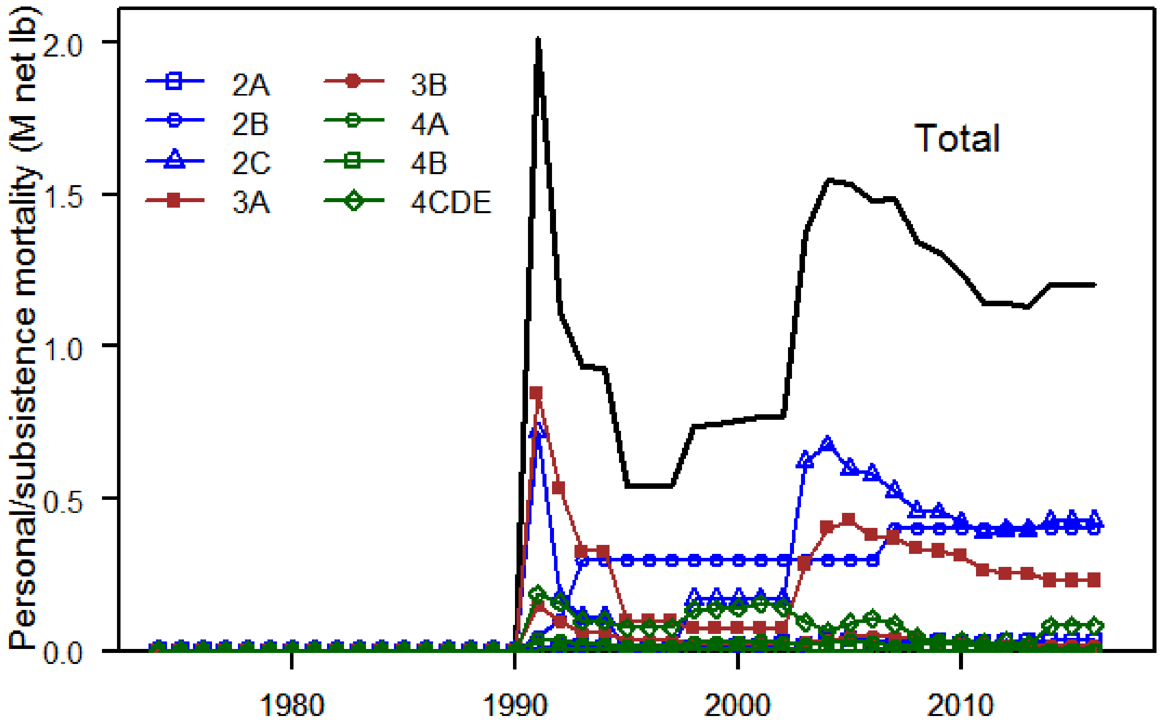
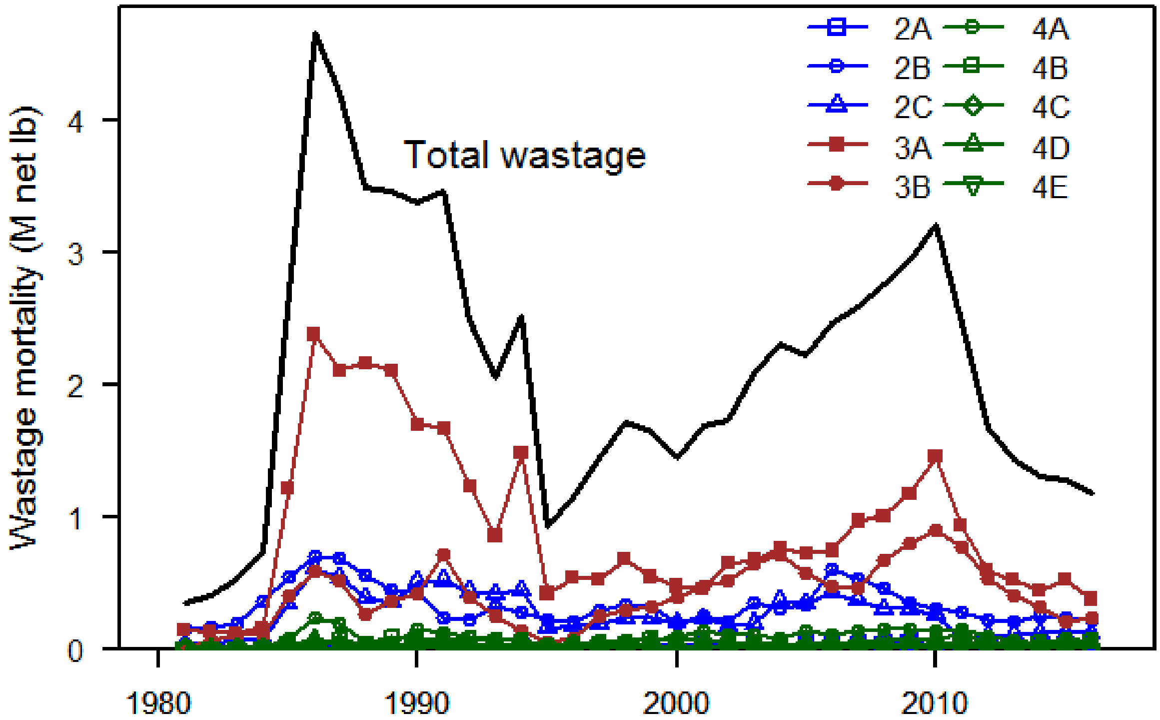


Figure 35. Estimated personal use or subsistence removals by regulatory area.



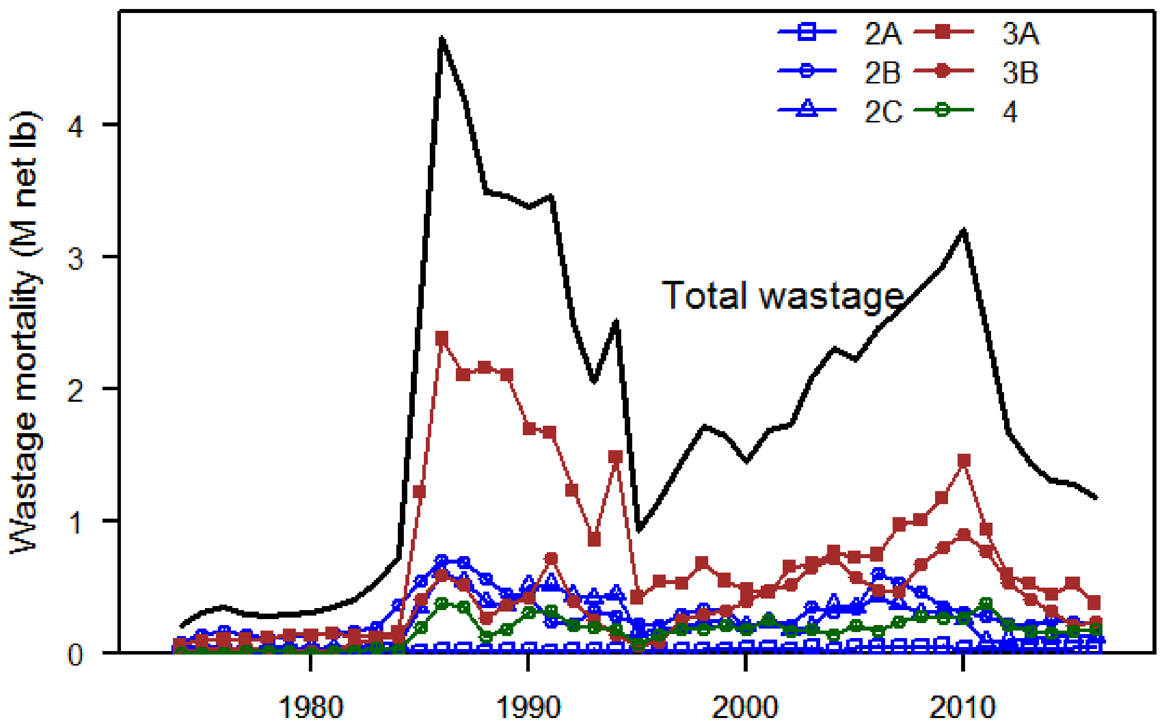


Figure 36. Wastage in the commercial fishery by regulatory area, 1981+ (upper panel), and 1974+, with all of Area 4 combined (lower panel).

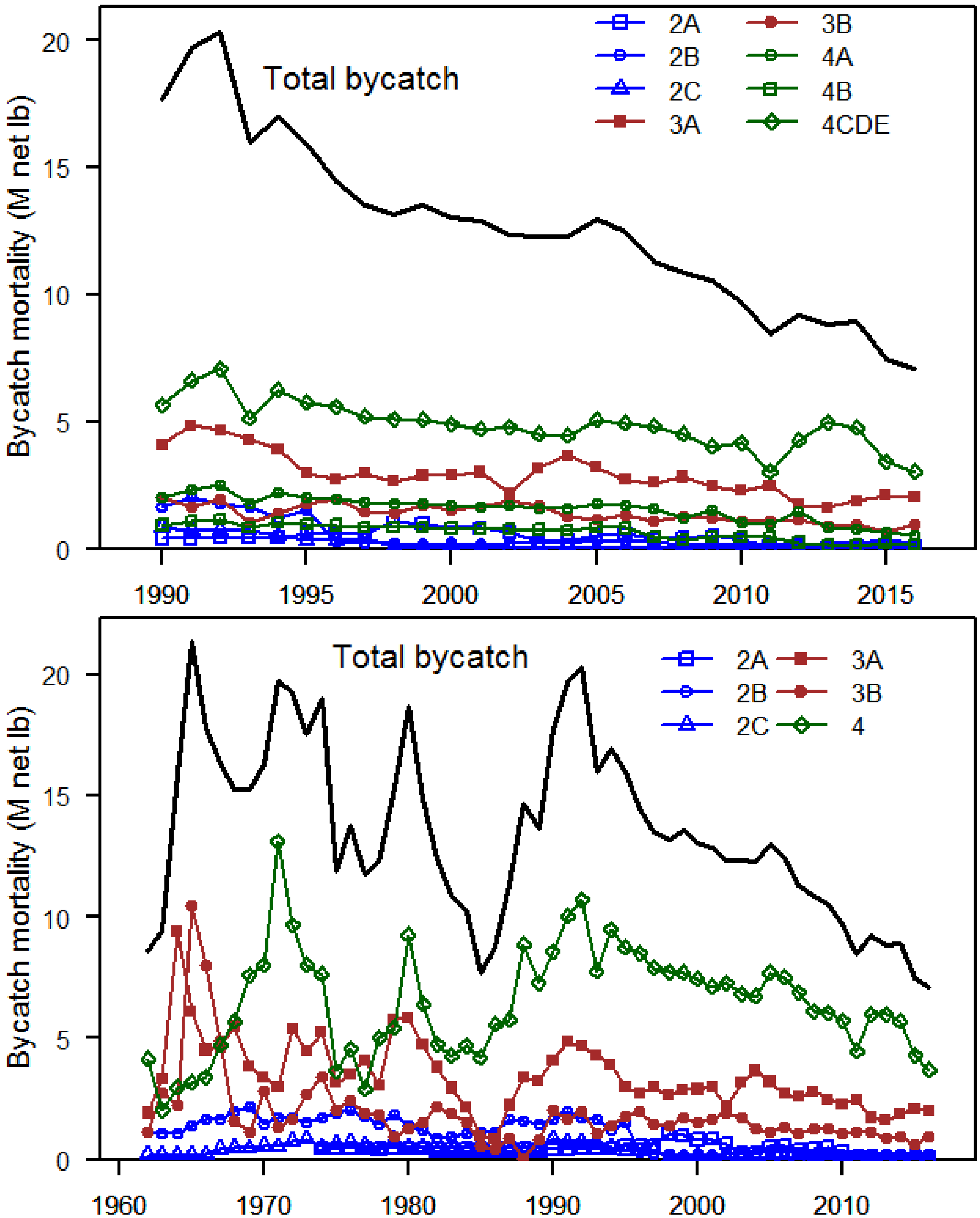


Figure 37. Pacific halibut bycatch estimates by regulatory area, 1990+ (upper panel), and 1962+, with all of Area 4 combined (lower panel).

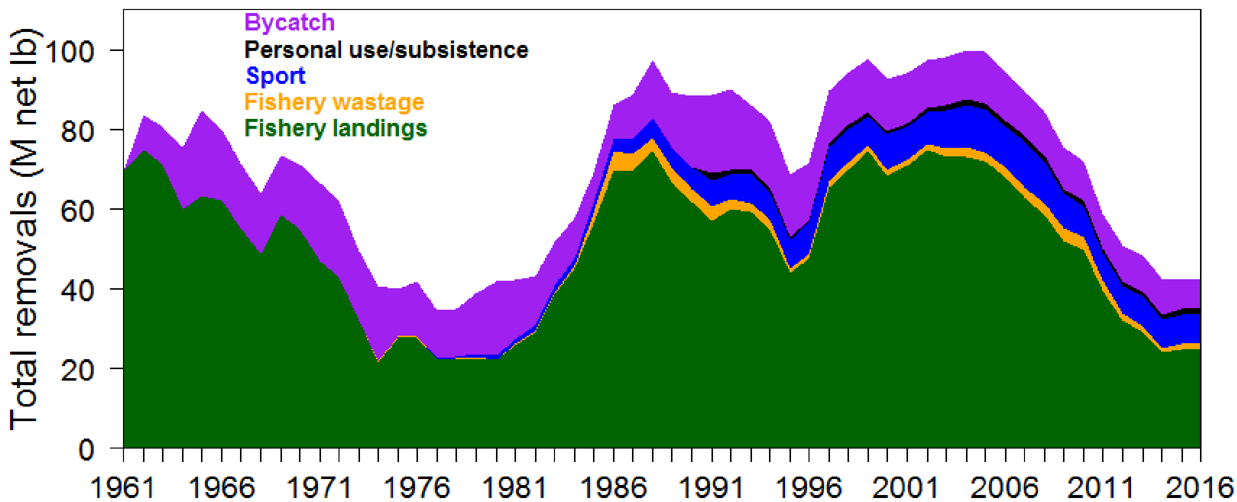


Figure 38. Total Pacific halibut removals by source since 1961.

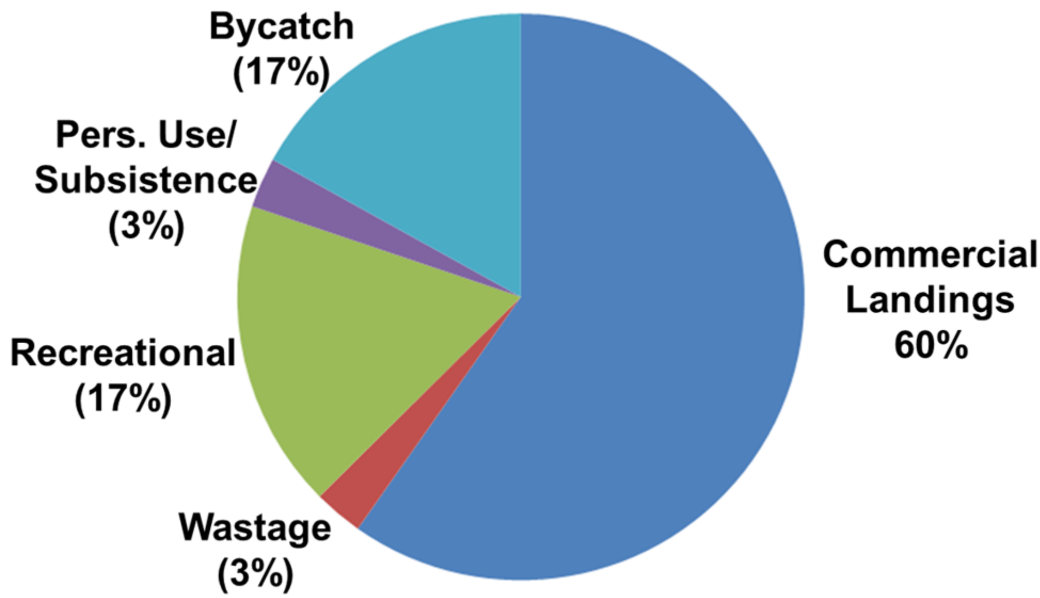


Figure 39. Distribution of Pacific halibut removals by source in 2016.

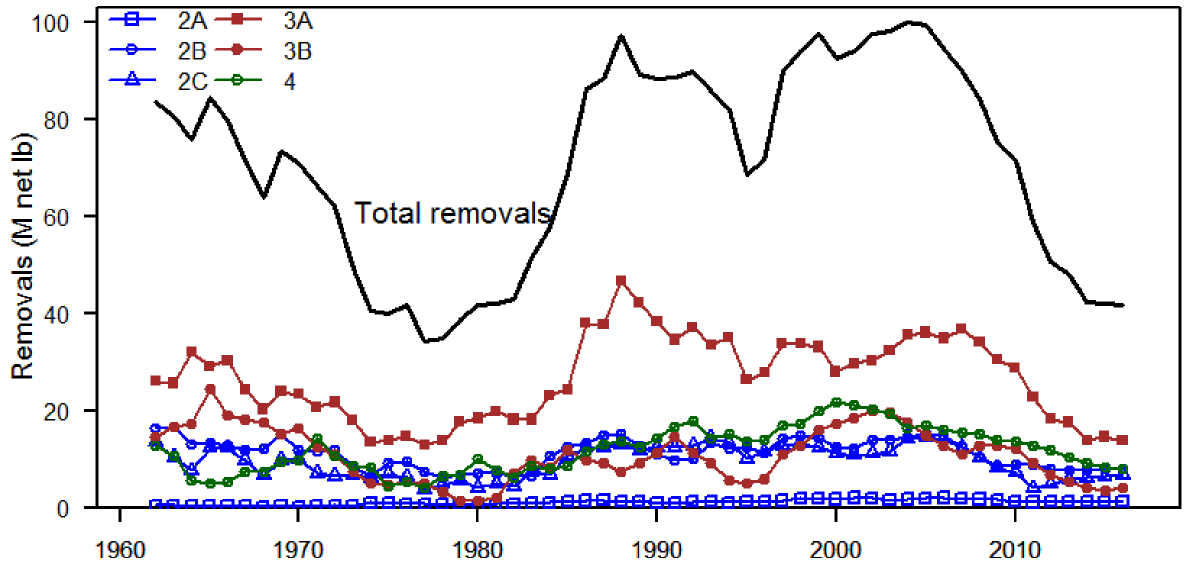


Figure 40. Total Pacific halibut removals by regulatory area since 1962.

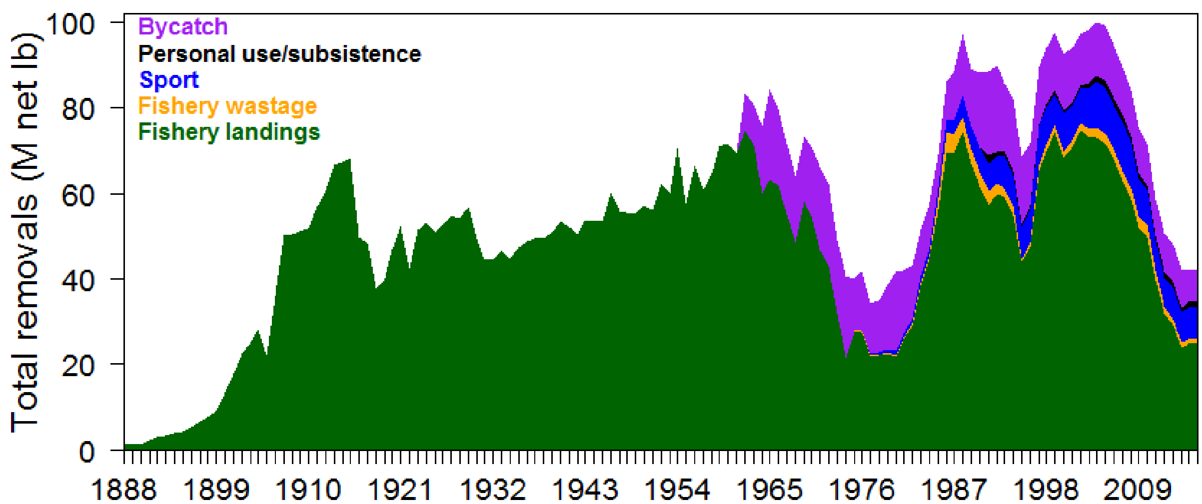


Figure 41. Total estimated Pacific halibut removals by source since 1888.

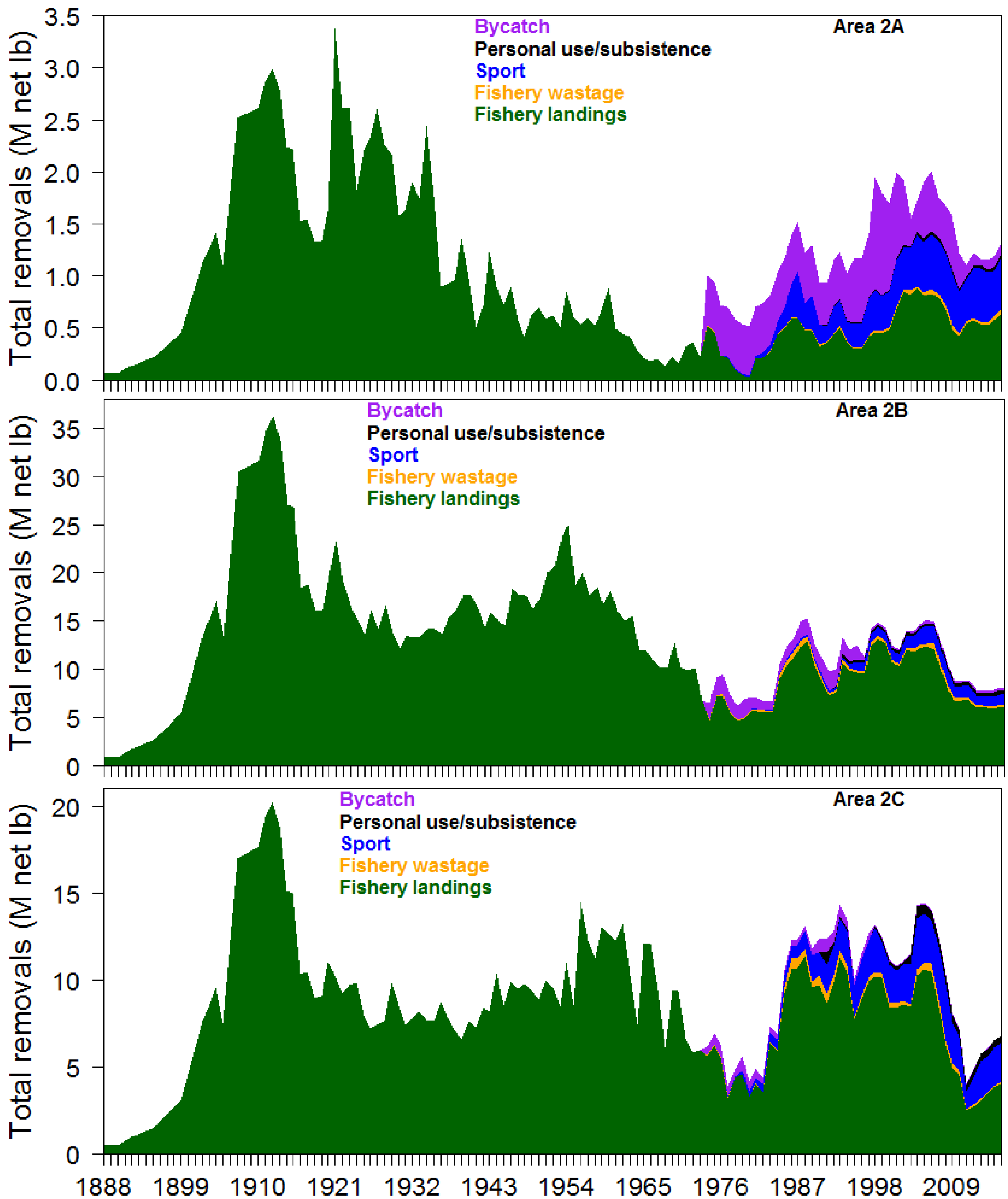


Figure 42. Total estimated Pacific halibut removals by source in Areas 2A, 2B, and 2C since 1888. Note that the y-axes differ in scale.

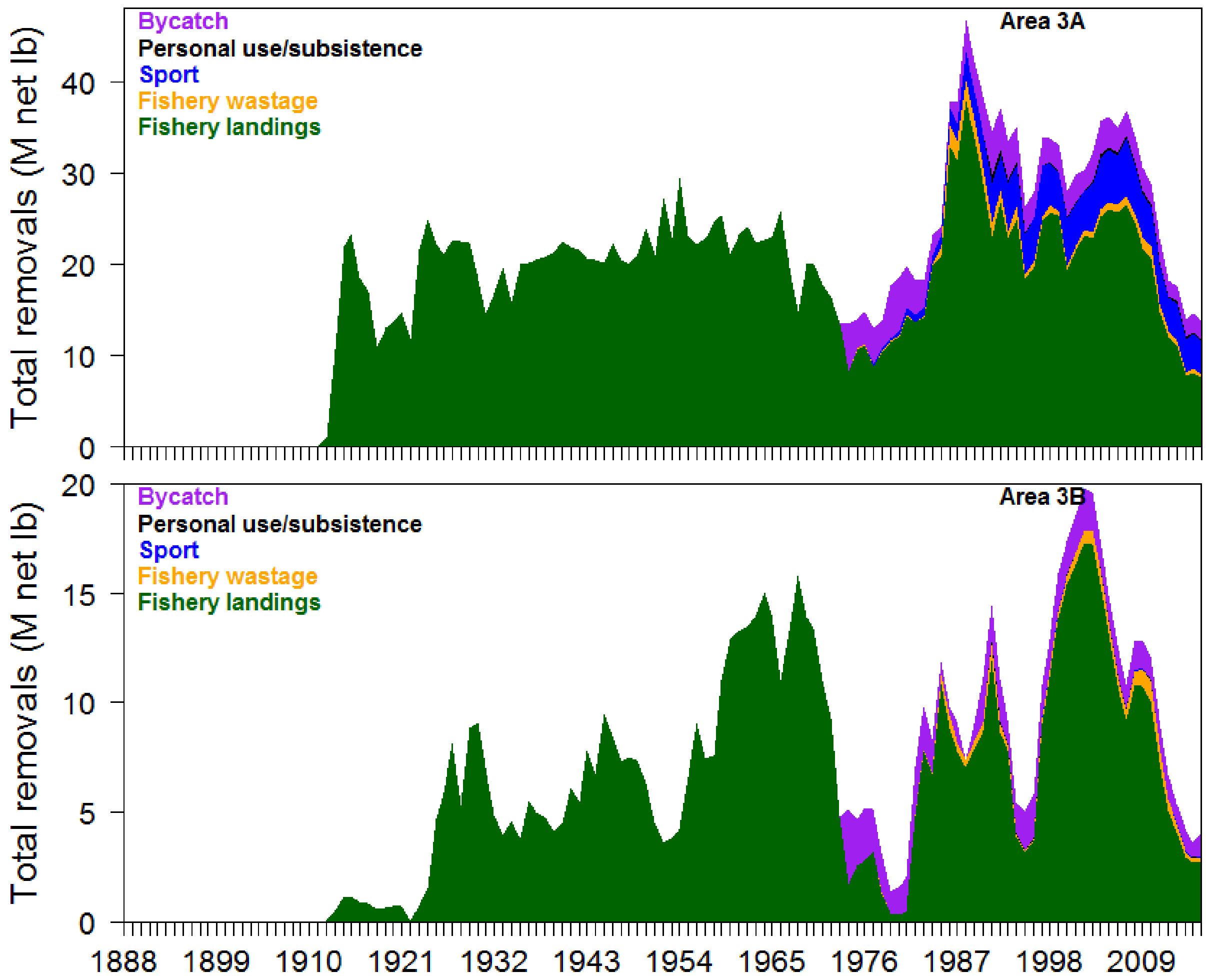


Figure 43. Total estimated removals by source in Areas 3A, and 3B since 1888. Note that the y-axes differ in scale.

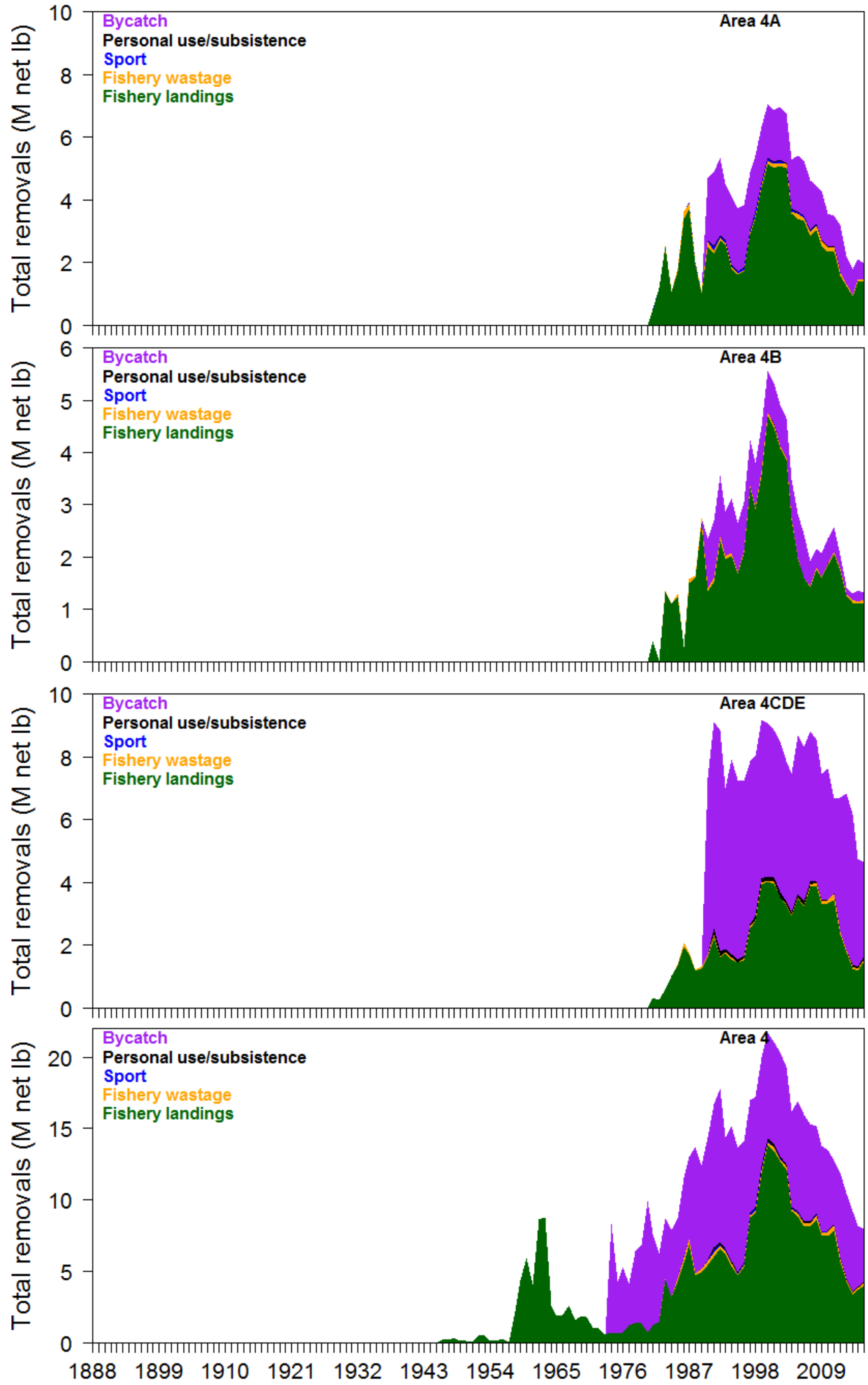


Figure 44. Total estimated removals by source in Areas 4A, 4B, 4CDE, and all of Area 4 combined since 1888. Note that the y-axes differ in scale.

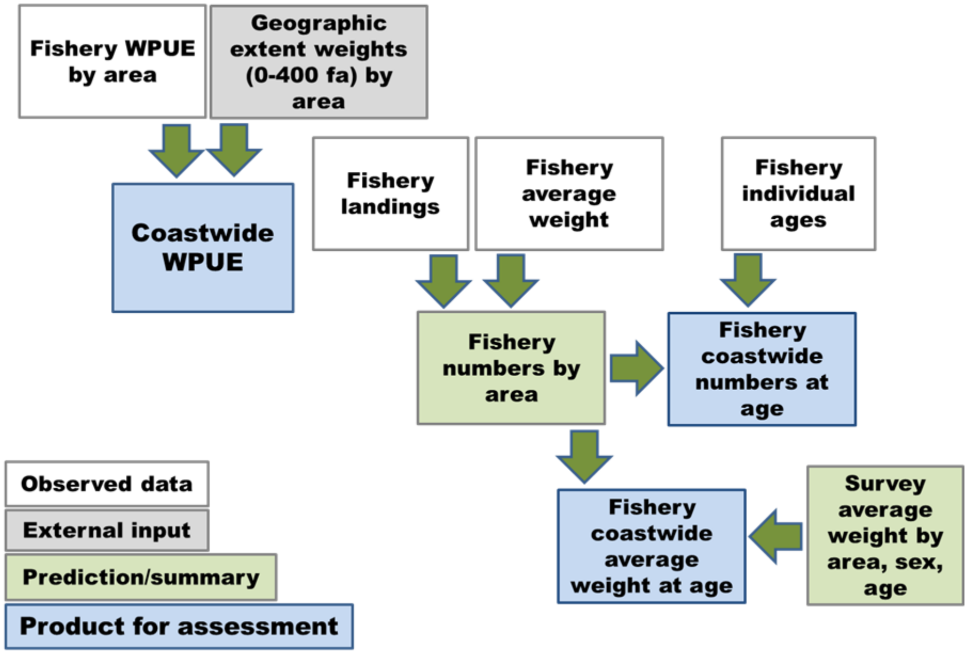


Figure 45. Relationships among fishery-dependent catch-rate and biological data sources.

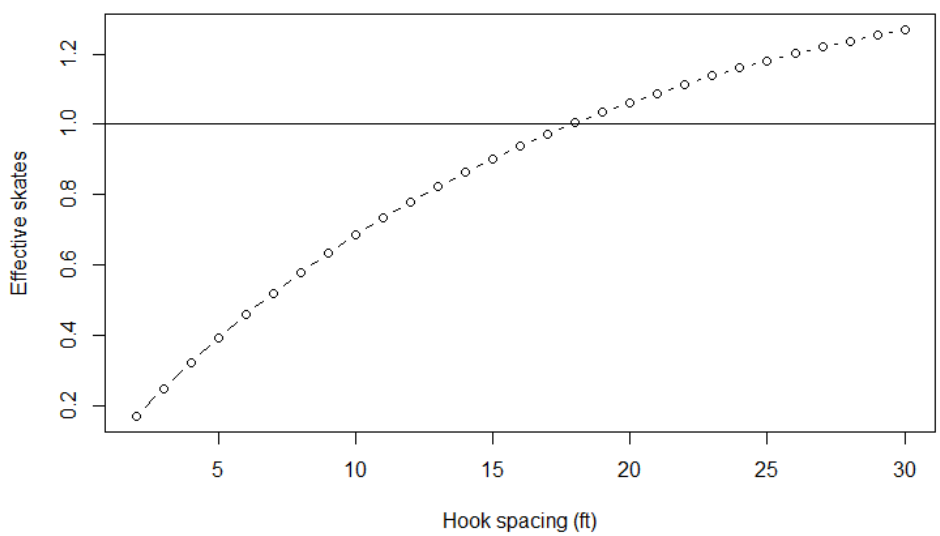


Figure 46. Relationship between hook spacing and the number of effective skates for set line survey and commercial fishery WPUE calculations (From: Hamley and Skud 1978).

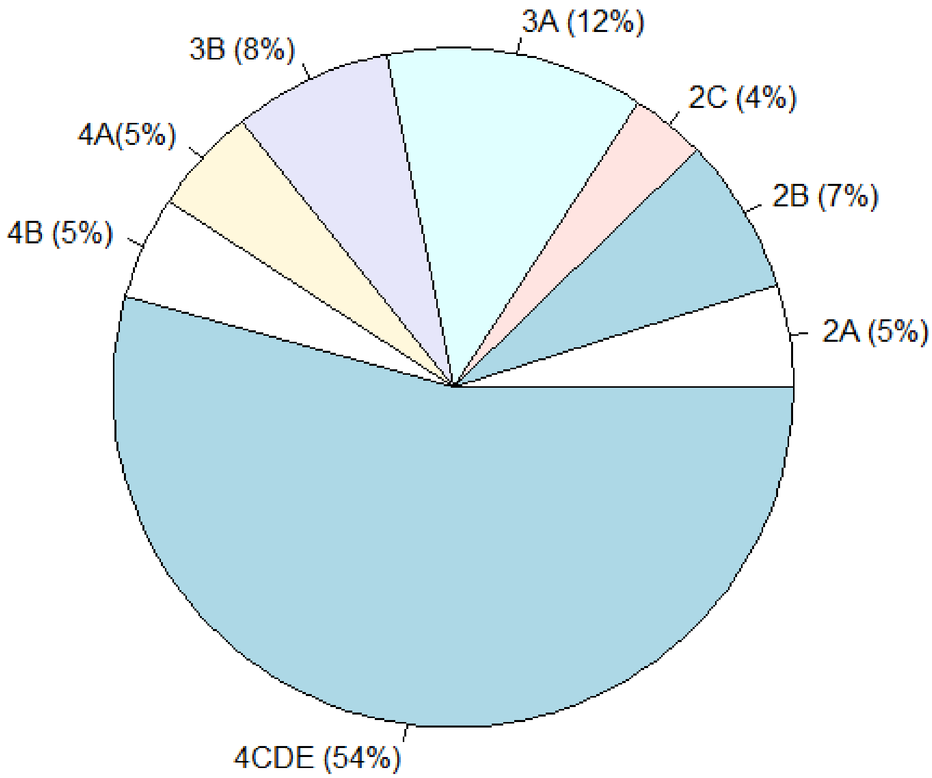


Figure 47. Relative spatial extent of each regulatory area.

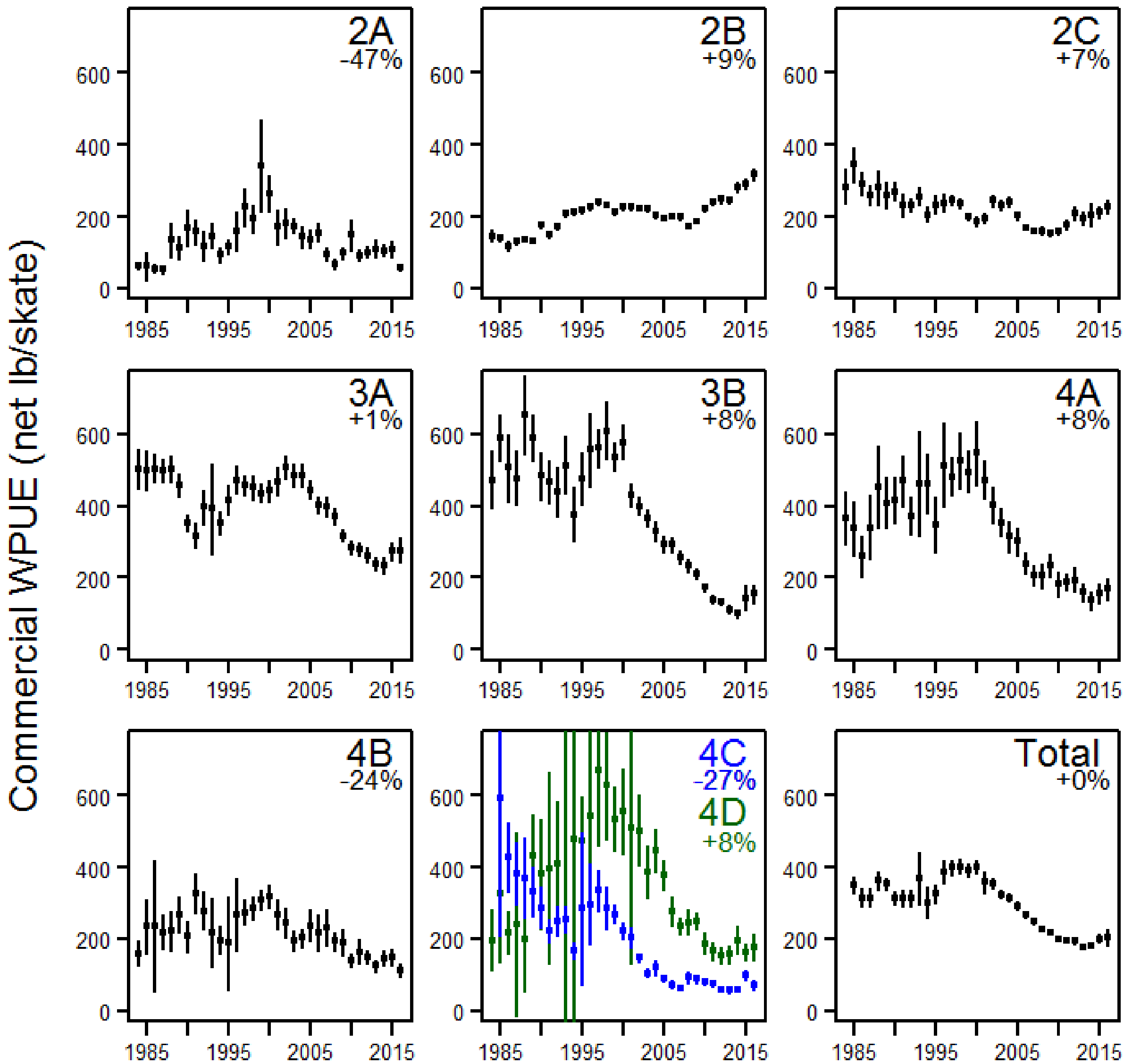


Figure 48. Commercial WPUE summarized by regulatory area and year. Percentages for each Area indicate the change from 2015 to 2016

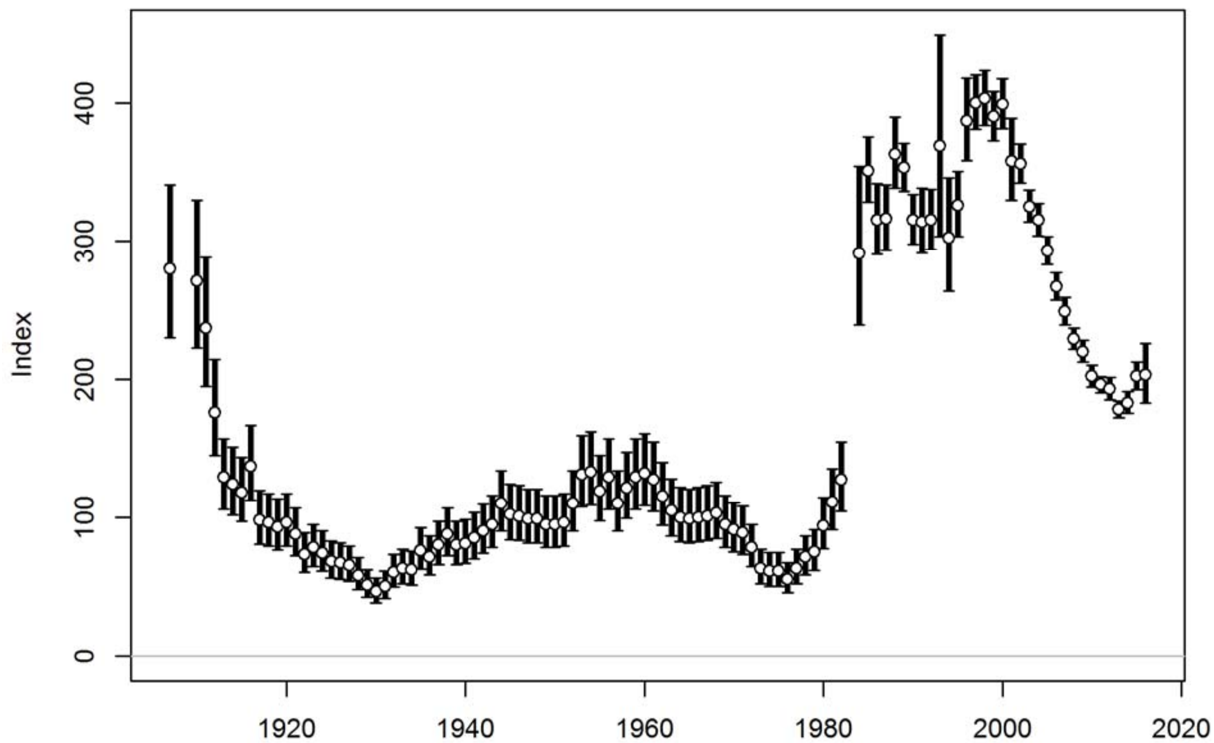


Figure 49. Coastwide commercial WPUE from historical records of effort and catch, as well as more recent direct logbook processing. The large change between 1982 and 1984 coincides with the adoption of circle hooks.

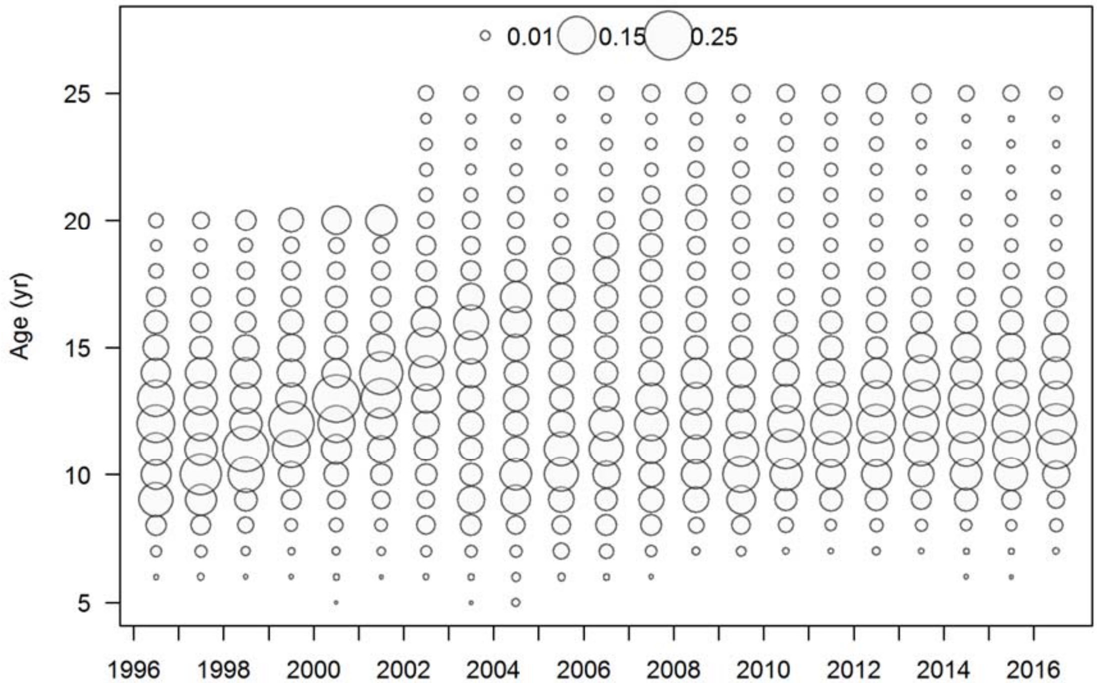


Figure 50. Estimates of recent commercial fishery numbers-at-age. Circles represent proportions that sum to 1.0 within each year.

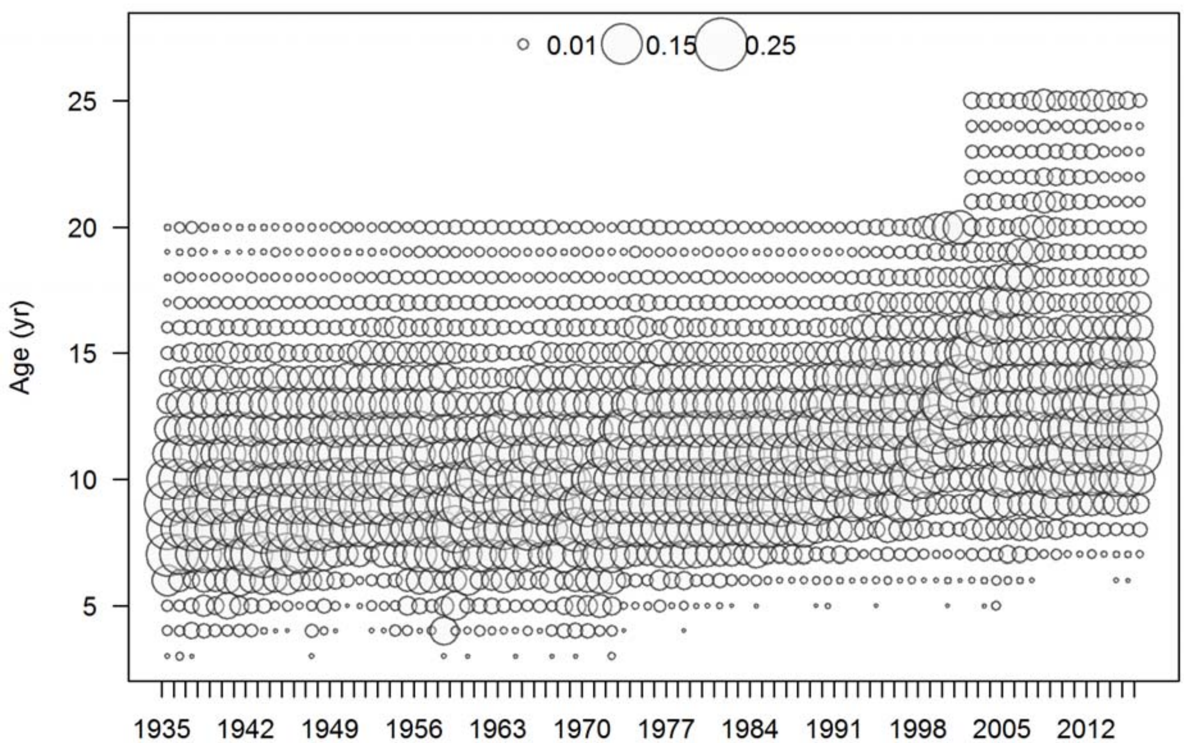


Figure 51. Coastwide commercial fishery proportions-at-age from the retained catch (male and female Pacific halibut combined). Note that the current 32 inch minimum size limit was implemented in 1973. Circles represent proportions that sum to 1.0 within each year.

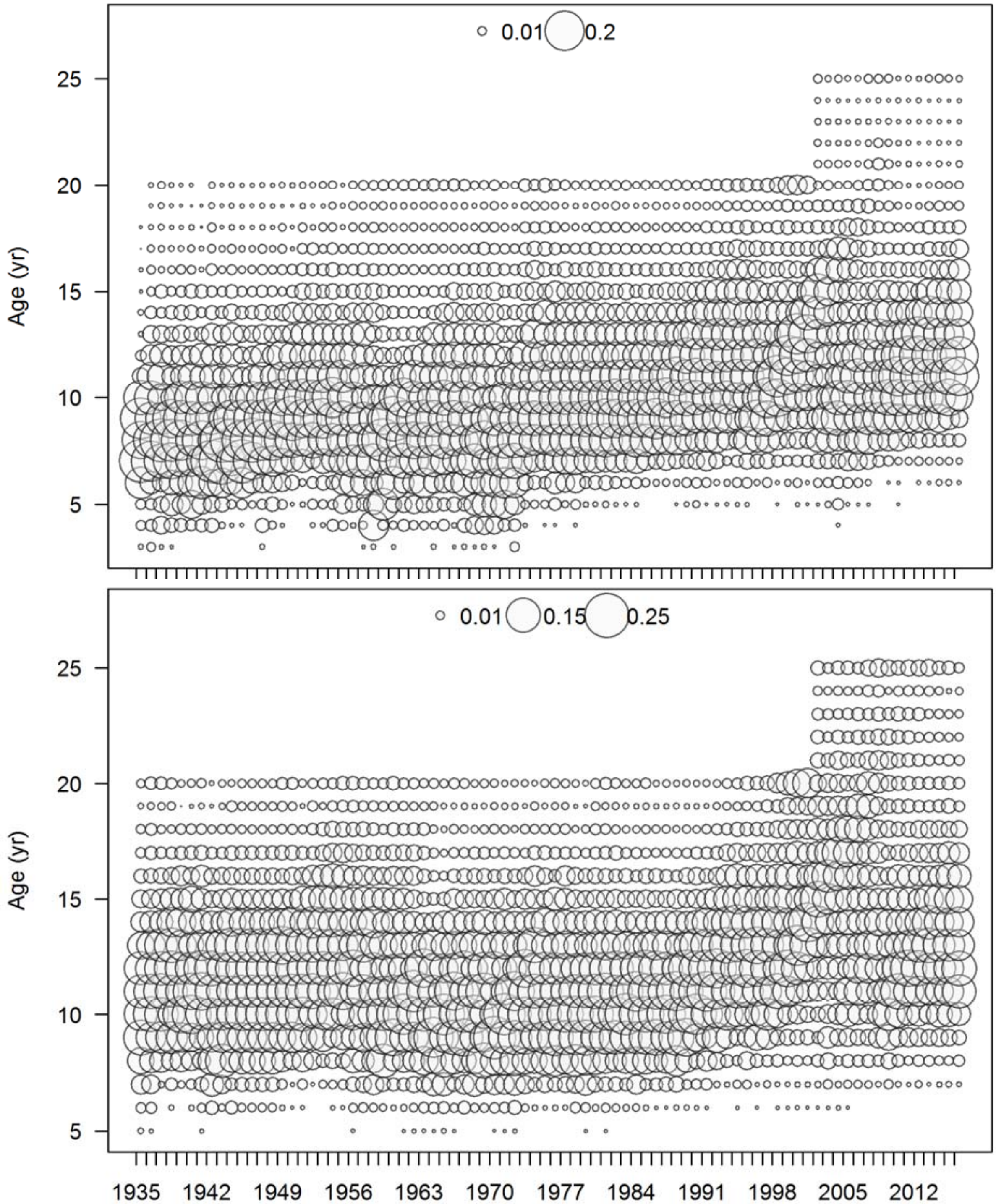


Figure 52. Commercial fishery proportions-at-age in the retained catch (male and female Pacific halibut combined) by geographic region: Area 2 (top panel), and Area 3 (bottom panel). Circles represent proportions that sum to 1.0 within each year.

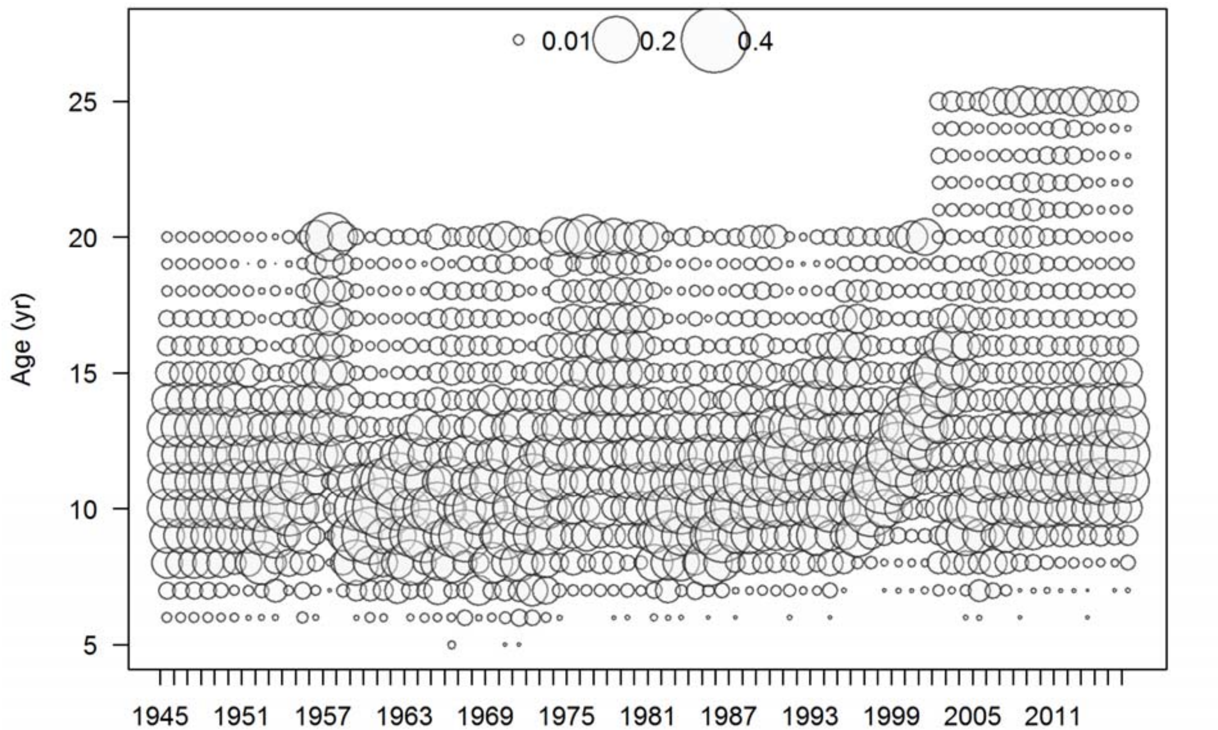


Figure 53. Commercial fishery proportions-at-age in the retained catch (male and female Pacific halibut combined) for Area 4. Circles represent proportions that sum to 1.0 within each year.

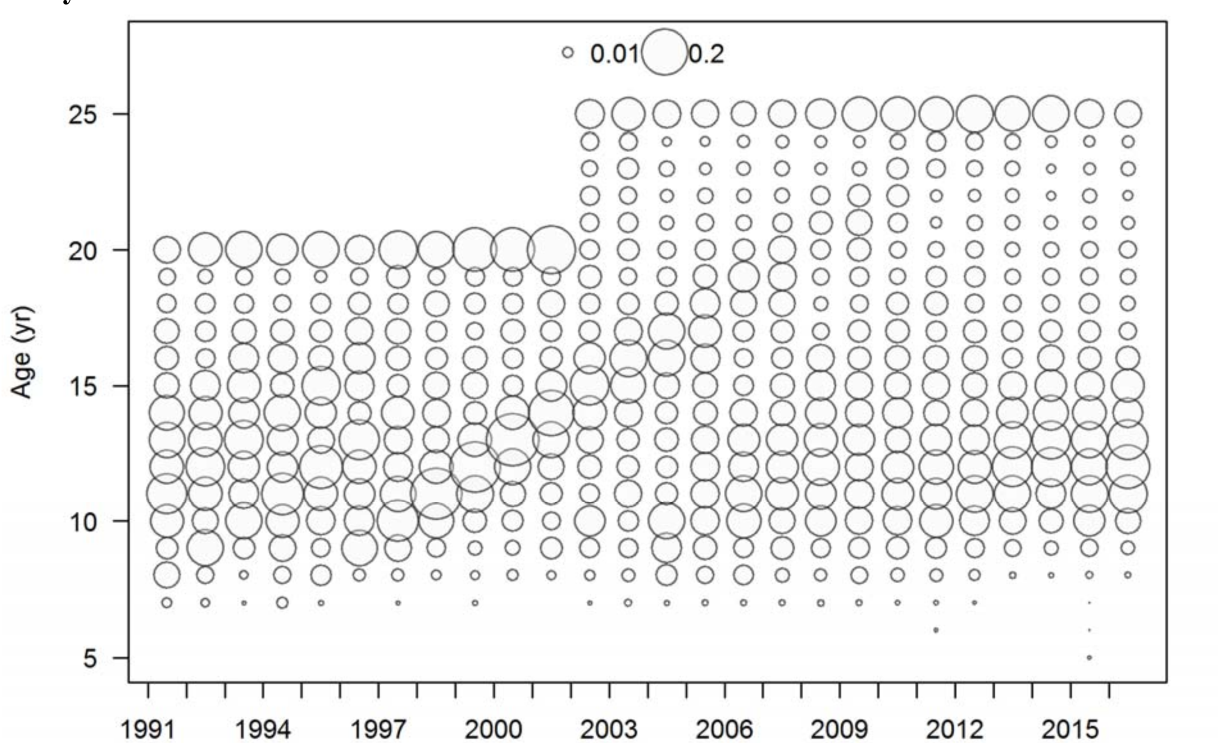


Figure 54. Commercial fishery proportions-at-age in the retained catch (male and female Pacific halibut combined) for Area 4B. Circles represent proportions that sum to 1.0 within each year.

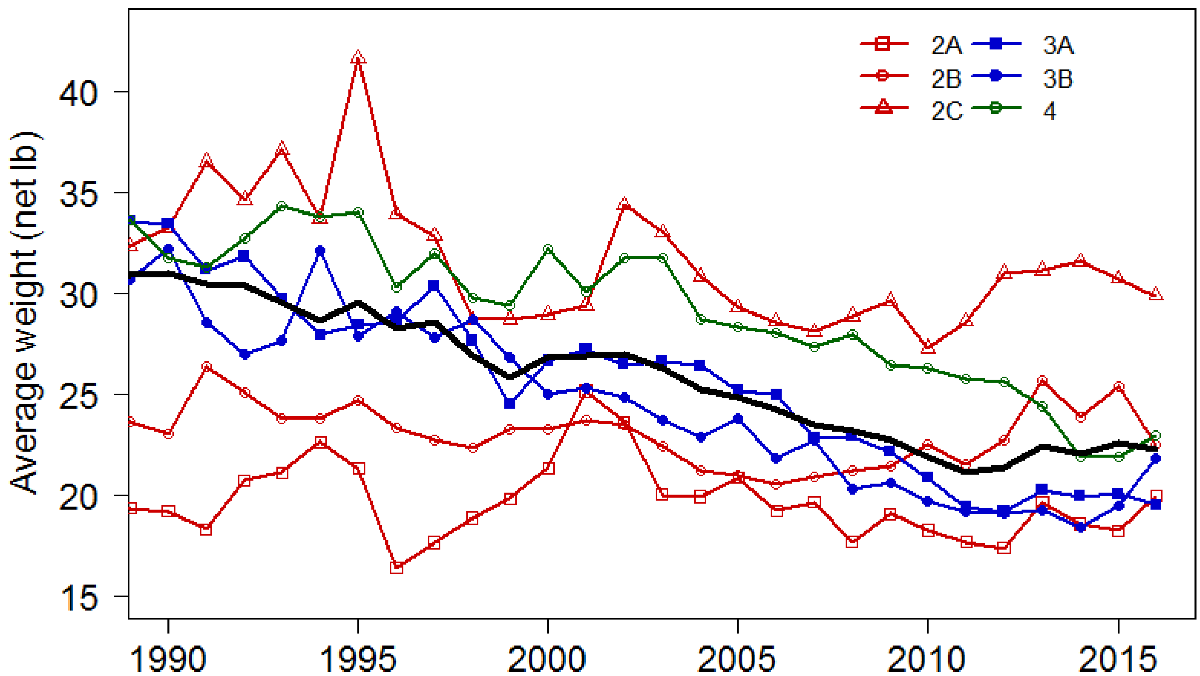


Figure 55. Recent average Pacific halibut weight by regulatory area in the directed fishery landings; thick black line indicates the coastwide average.

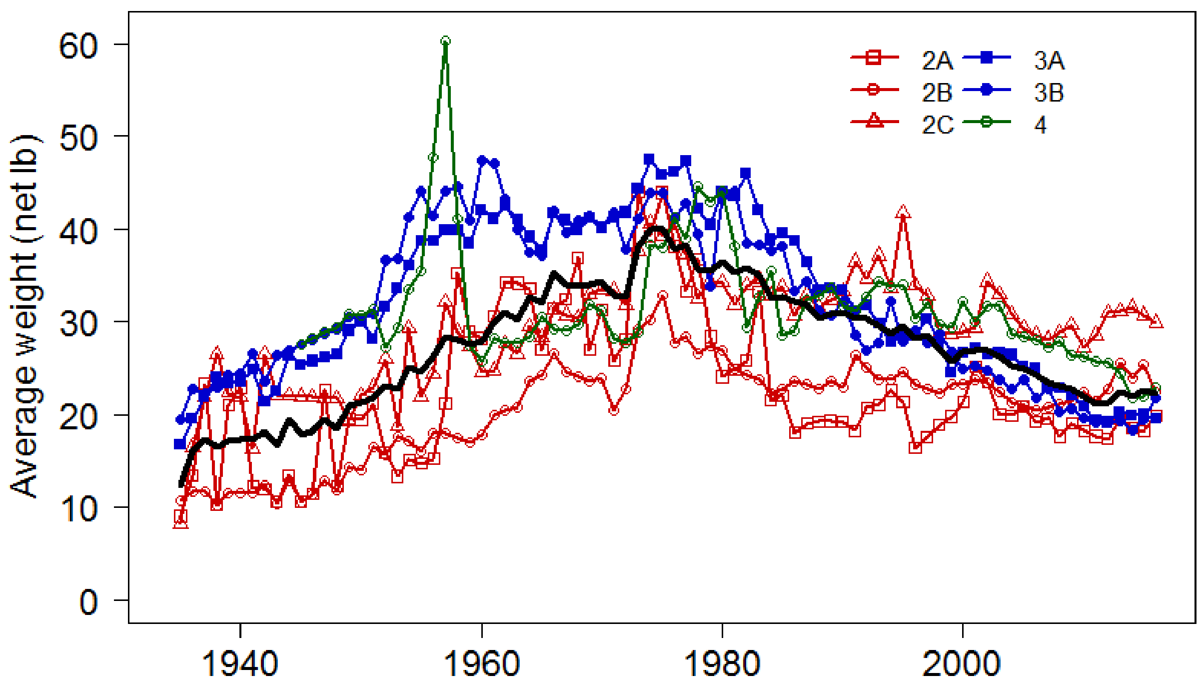


Figure 56. Historical trends in average individual Pacific halibut weight in the commercial fishery landings; thick black line indicates the coastwide average. The current 32-inch (81.3cm) minimum size limit went into effect in 1974.

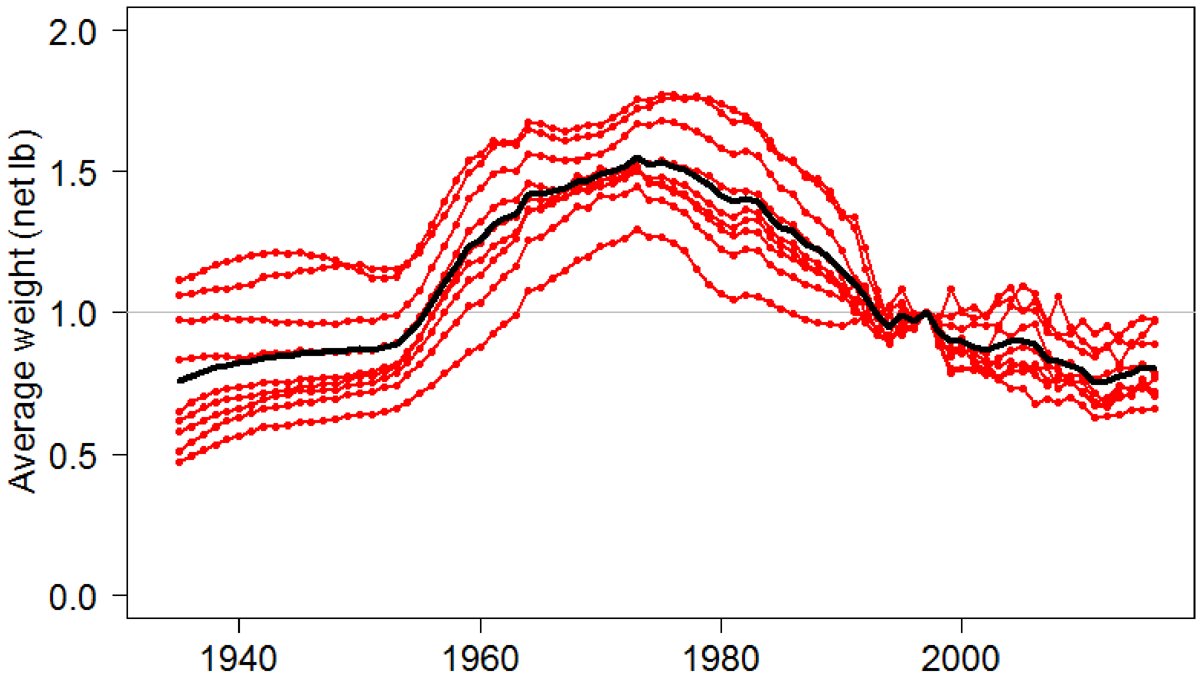


Figure 57. Trends in coastwide average individual Pacific halibut weight as deviations from 1997 in the commercial fishery landings for Pacific halibut aged 8-16 years old (red lines). The black line represents the average trend among the nine ages included.

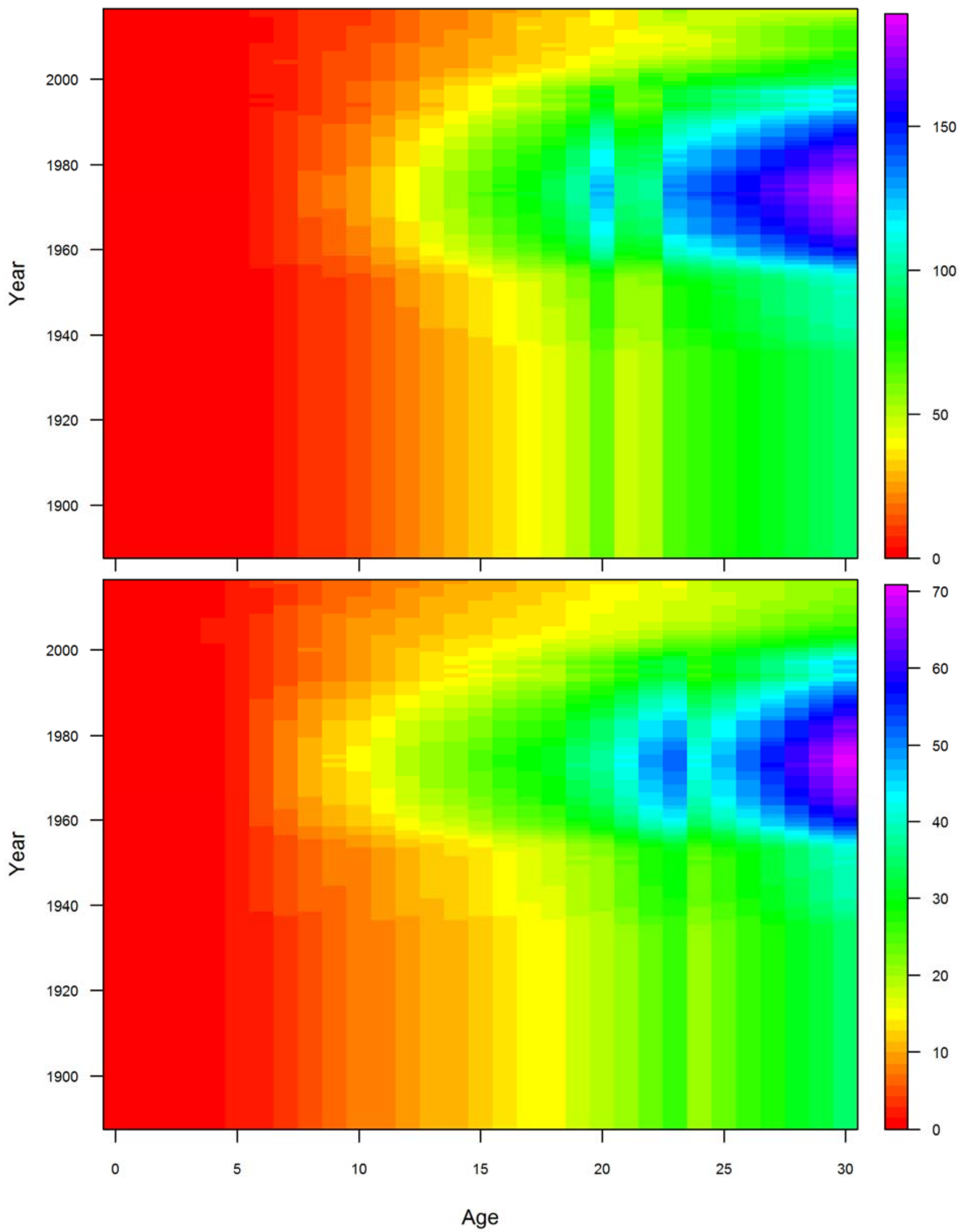


Figure 58. Time series of coastwide weight-at-age (net lb) for female (upper panel), and male (lower panel) Pacific halibut from all regulatory areas (note that the scale differs between panels).

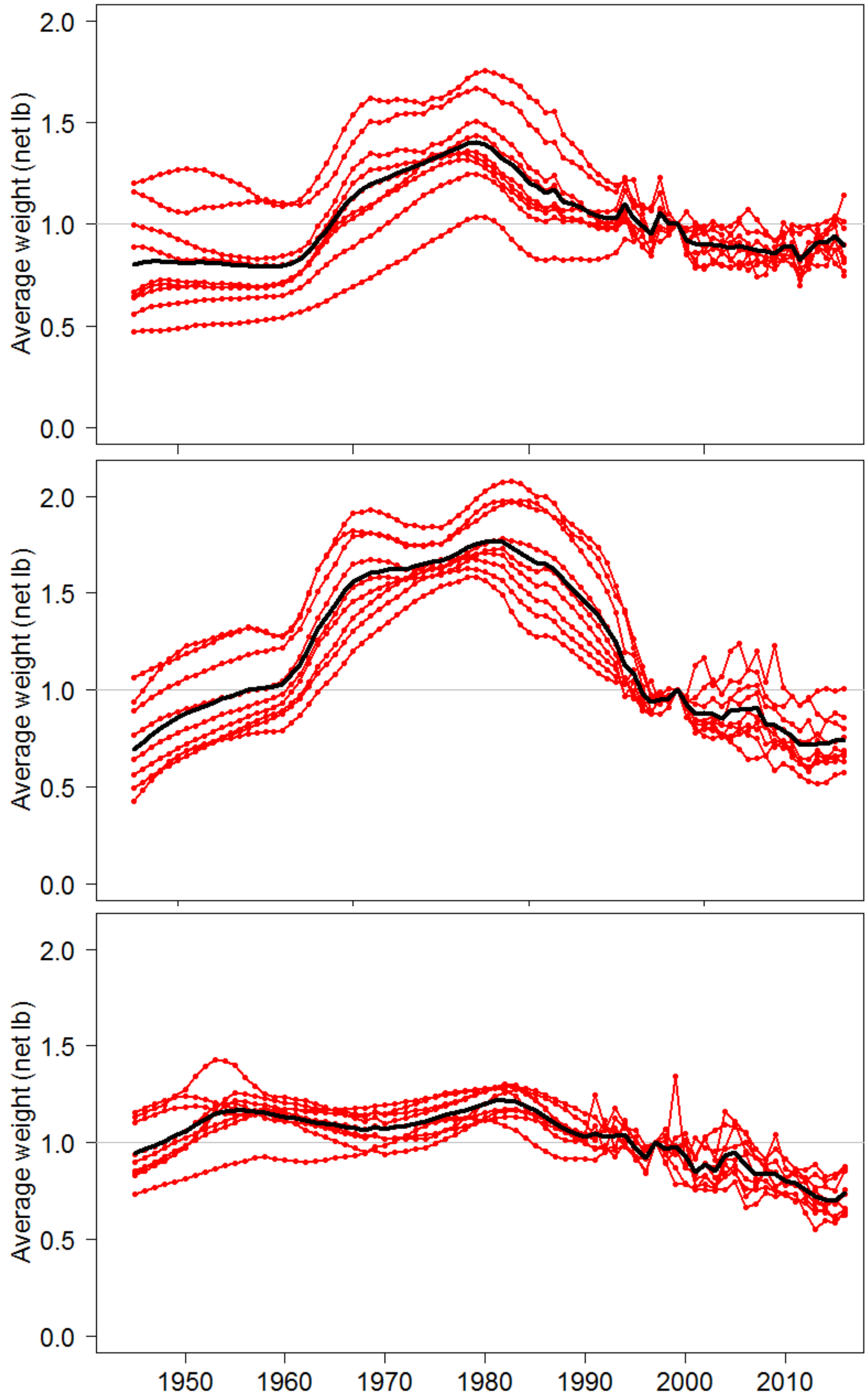


Figure 59. Trends in specific average individual Pacific halibut weight as deviations from 1997 in the commercial fishery landings for Pacific halibut aged 8-16 years old (red lines) from Area 2 (upper panel), Area 3 (middle panel), and Area 4 (lower panel). The black lines represent the average trend among the nine ages included.

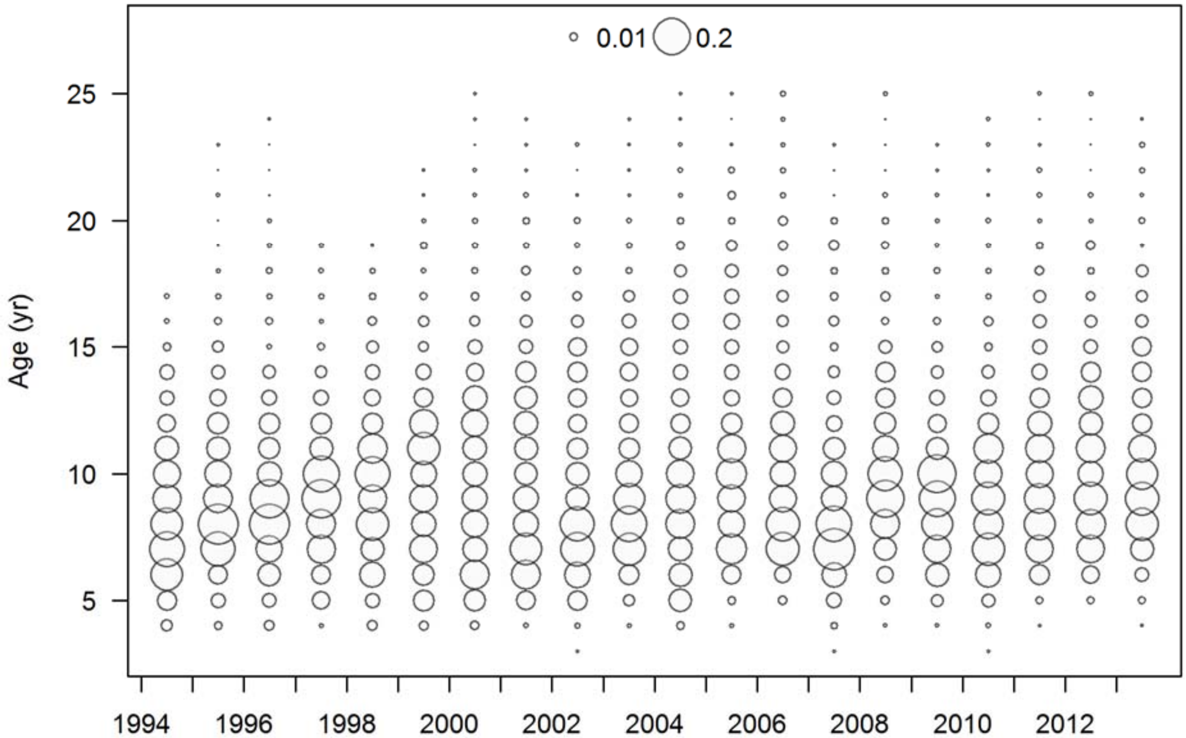


Figure 60. Proportions-at-age from the recreational fishery in Area 3A (male and female Pacific halibut combined). Circles represent proportions that sum to 1.0 within each year.

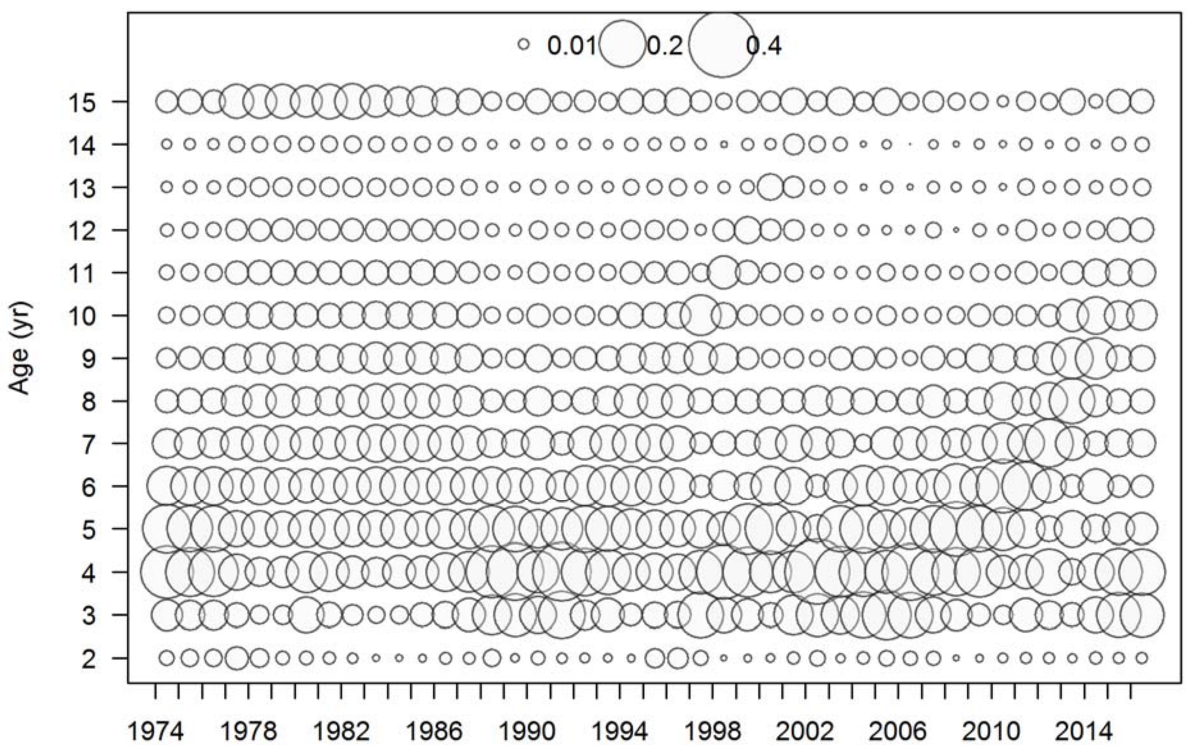


Figure 61. Coastwide proportions-at-age from the aggregate bycatch fisheries (male and female Pacific halibut combined). Circles represent proportions that sum to 1.0 within each year.

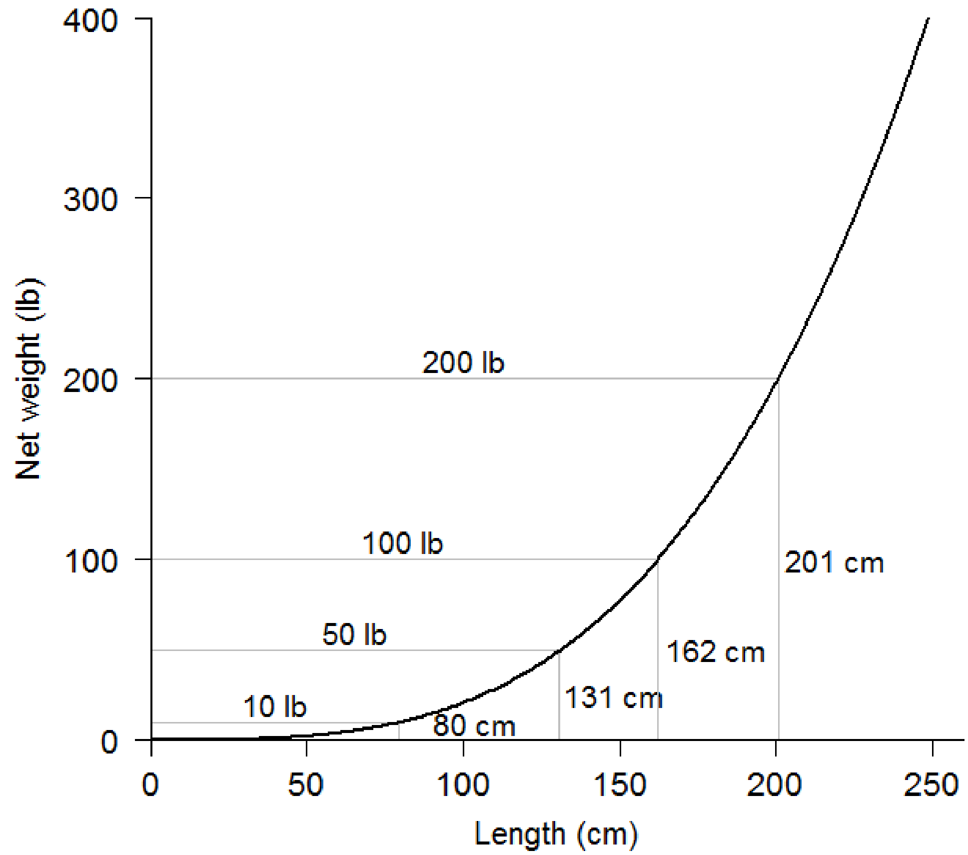


Figure 62. The conversion relationship for length in centimeters to net weight in pounds.

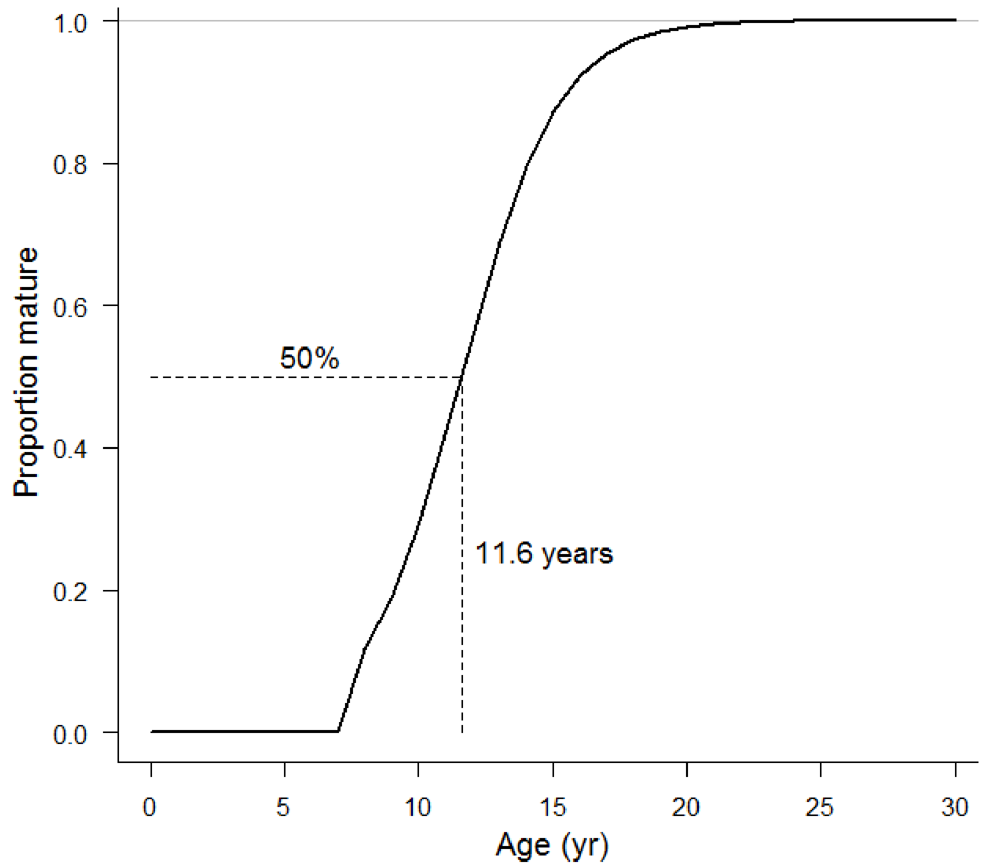


Figure 63. The maturity ogive used in recent Pacific halibut assessments. Note that this is a logistic curve, trimmed to be equal to zero below age-8.

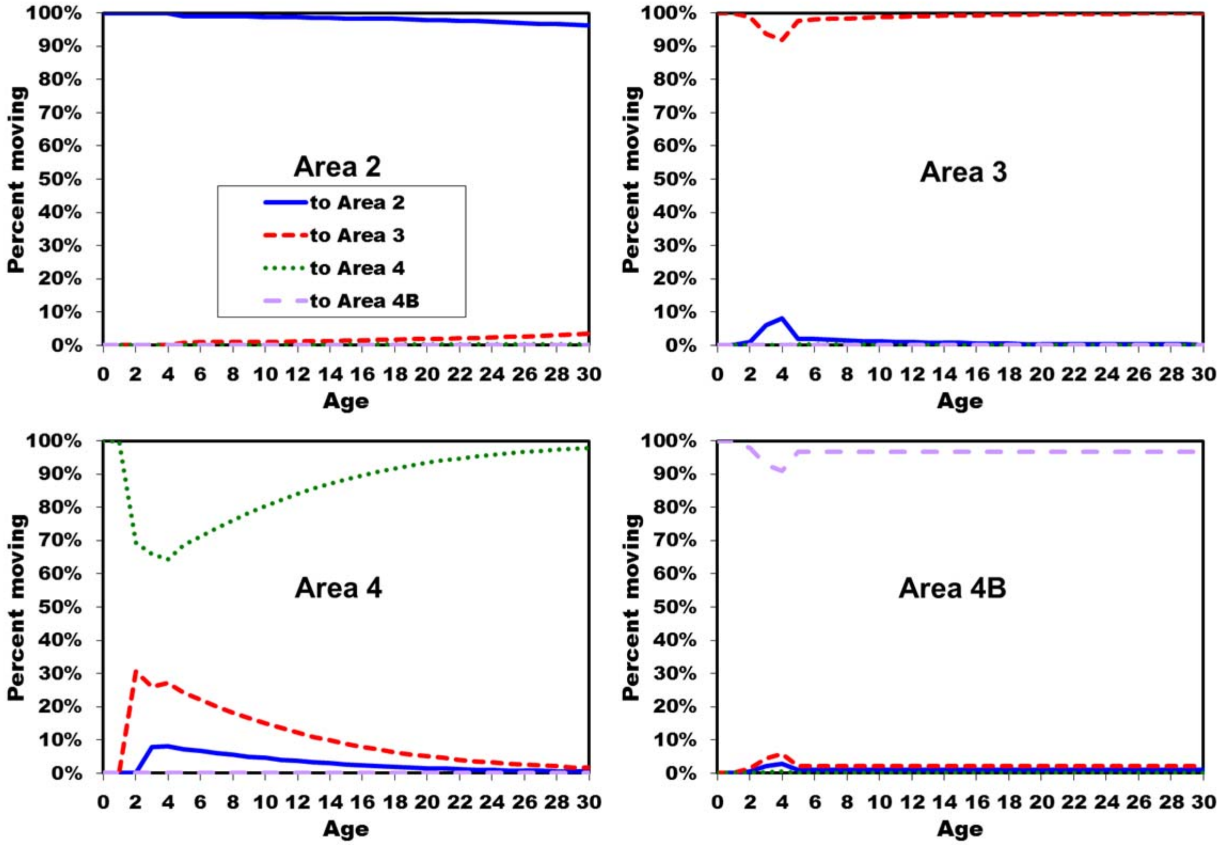


Figure 64. Hypothesized annual movement rates by age among geographic regions.

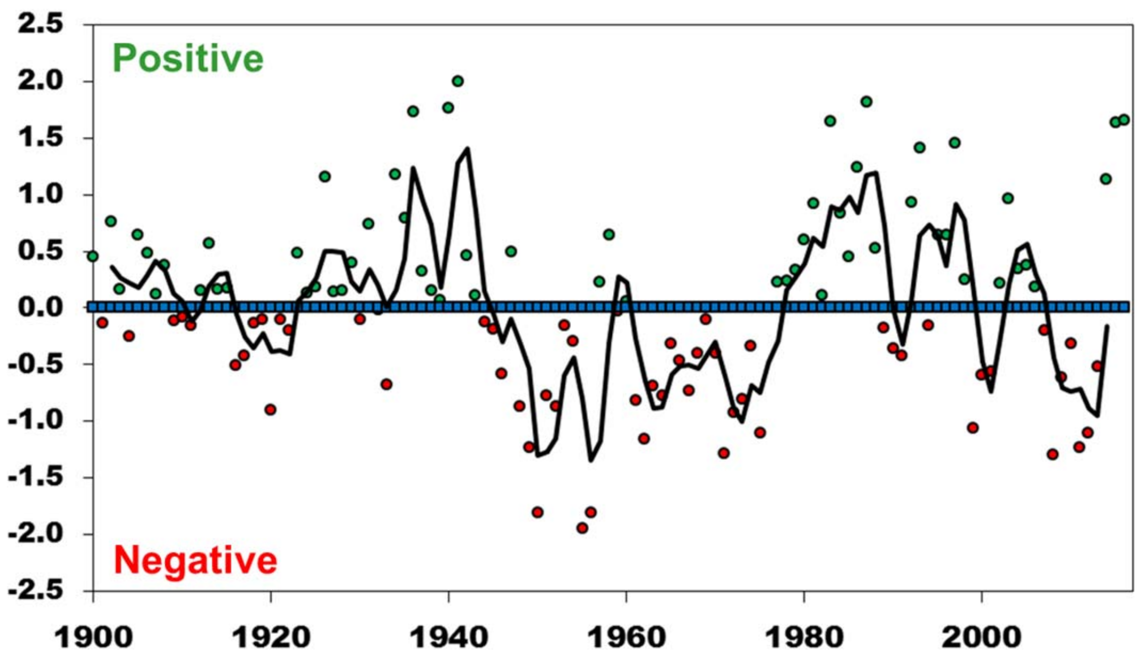


Figure 65. Time series of annual average PDO conditions (deviations from the long-term mean). Monthly means were obtained from http://jisao.washington.edu/pdo/ **.**