MEMORANDUM STATE OF ALASKA

DEPARTMENT OF FISH AND GAME

Division of Commercial Fisheries

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DATE: 3/16/2017

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SUBJECT: 2017 NSEI Sablefish Assessment

Summary Table			
Quantity	**2016**	**2017**	**Percent change**
Forecast exploited abundance	1,445,938	1,564,409	+ 8.19%
Forecast exploited biomass	12,951,596	13,502,591	+ 4.25%
F ABC = F 50%	0.0677	0.0683	+ 0.89%
ABC – F50% (round pounds)	**807,559**	**850,113**	+ 5.27%
ABC – F45% (round pounds)	954,364	1,005,851	+ 5.39%
ABC – F40% (round pounds)	1,126,343	1,189,083	+ 5.57%

Summary

- The 2017 Allowable Biological Catch (ABC) for Northern Southeast Inside Waters (Chatham Strait) at a fishing mortality level of $F_{50\%}$ is 850,113 round pounds. This is a 42,553 pound increase (5.27%) from the 2016 ABC.
- The proportion of females observed in the fishery catch continues to be greater than the proportion observed in the longline survey for all ages.
- Catch per unit effort (numbers) for the ADF&G Chatham Strait longline survey increased relative to 2015 by 10.3% and by 4.5% in weight. The commercial longline fishery CPUE increased 14.9%
- The federal stock assessment for sablefish in the Gulf of Alaska (GOA) has reported an increase in abundance and in the associated quota. The recommended federal ABC for

the 2017 commercial longline sablefish fishery is 13,083 t, a 10.9% increase from the 2016 ABC of 11,795 t (Hanselman et al. 2016).

Changes to the NSEI sablefish assessment for 2017 relative to 2016

1. Previously the mark-recapture estimate of abundance was calculated by allocating a sex to released individual fish, based upon the fishery sex ratio at age. This allocation was removed and the population abundance was determined without a sex ratio. This slightly reduced the abundance estimate from the 2015 mark-recapture project. Note that no mark-recapture project was implemented in 2016 therefore the population abundance was estimated on 2015 mark-recapture data. Once the abundance was calculated the estimate was then partitioned by sex based upon the sex ratio in the fishery.
2. Partitioning mark-recapture estimates of abundance into age-specific cohorts previously included ages 4 - 42+ with the assumption that retention of age 2 and 3 fish in the commercial longline fishery was limited. However, during 2016 age 2 and age 3 fish have been retained in the commercial fishery therefore these younger ages are now included in the mark-recapture estimation.

2016 Acceptable Biological Catch (ABC)

The 2015 pot survey released 6,859 marked fish. A natural mortality of 0.1 (Johnson and Quinn 1988) was applied to all fish for the time period between marking and recapture. Individual fish recovered outside NSEI waters or in the ADF&G longline survey, or for whom location could not be determined were removed from the population analysis. Scaling for fishery selectivity, a total of 5,637 marked fish were available to be recovered in the commercial longline fishery. Of these marked fish, 242 were recovered during the NSEI commercial longline fishery of 70,031 fish examined by ADF&G port samplers. The mark-recapture point estimate of total exploited abundance for 2016 was 1,597,579 individuals (Note that this number is different than that presented in the 2016 stock assessment due to the removal of sex specific tag releases). Partitioning into sex-specific age-classes from 2016 commercial fishery catch-at-age/sex data and projecting into 2017 produced an exploited abundance estimate of 1,564,409 individuals. Abundance multiplied by mean commercial fishery weight-at-age produces an estimate of 13,502,591 round pounds of exploited biomass.

Mark-Recapture Estimator

The mark-recapture project is the basis of current sablefish management in Chatham Strait, and serves to scale absolute abundance in the age structured assessment model. Each year that the mark-recapture project is implemented, individual sablefish from Chatham Strait are captured in May using pots and released with a Floy tag. Any tagged fish caught between the marking event and the beginning of the commercial fishery (August) are removed from the population estimate. The commercial fishery is treated as the recovery event, with catches examined at various ports and the number of tagged and untagged fish recorded.

Data were adjusted each year such that:

1. Fish marked in the pot survey were binned into 10 cm length increments between 40 cm and 110 cm, the total number of marked fish *M* available to recapture events was the summed product of selectivity-at-length for the recovery gear (i.e. the *longline survey* selectivity-at-length) and the total number of marked fish present in a given length bin. This produces the total number of marks available to be recovered in the *vulnerable population*.
2. Recaptured fish were divided into males and females according to the sex-ratio of males and females within the commercial fishery.
3. Following Robson and Regier (1964), recaptured fish were binned into sample sizes based on the total number of potentially recoverable tags and the desired precision of the resulting abundance estimate. This meant that the total number of sampling time periods for any given year varied.

t_i	=	time in days since last event *i* (or since marking, if *i* == 1)
M_0	=	total number of marks available to be recovered by the commercial longline fishery gear
M_i	=	total number of marks available for recovery during a recovery event *i*
n_i	=	number of fish examined at event *i*
m_i	=	number of tagged fish recovered in event *i*
m_{early}	=	number of marks recovered after tagged release but before opening of the commercial fishery
mort	=	natural mortality decremented daily and set to 0.1 following Johnson and Quinn (1988)
$\hat{N}_i$	=	estimated total *exploited* abundance of population at event *i*
$\hat{N}$	=	estimated total *exploited* abundance of population prior to the first recovery event *i* (that is, at the beginning of the commercial longline fishery).

The probability in a given year of recapturing *m* marks given the number of examined fish n and probability of capture *p* is

$$Pr(m|n,p) = \binom{n}{m} p^m (1-p)^{n-m}.$$

Where

$$p = \frac{M_0}{\hat{N}}.$$

The final estimate of $\hat{N}$ for each year is obtained by minimizing the negative log-likelihood using AD Model Builder (ADMB) (Fournier et al. 2011). This pooled estimator produces an estimate of average exploited abundance halfway through the commercial fishery. The variance is estimated via applying the delta method to the variance-covariance matrix constructed by ADMB.

Determining Allowable Biological Catch

Vulnerable abundance-at-age for ages 2+ is calculated by partitioning the estimated exploited abundance into cohorts according to the commercial fishery catch-at-age proportion and forecasting by one year as

$$\hat{N}_{t,a} = \sum_{k=1}^{2} \left[\frac{\hat{N}_{t-1,a-1}\phi_{k,t-1,a-1}}{s_{k,a-1}} s_{k,a} \right]^{-((s_{k,a-1})(F_{t-1}/2)+M)}$$

where

$\hat{N}_{t,a}$= the estimated exploitable abundance-at-age *a* in year *t*,
$\hat{N}_{t-1}$= the estimated total exploitable abundance for year *t-1*,
$s_{k,a-1}$ = the commercial fishery selectivity at age *a-1* for gender *k*,
$s_{k,a}$ = the commercial fishery selectivity at age for age *a*, gender *k*,
$\phi_{t-1,a-1}$= fishery catch-at-age proportion for gender *k* at age *a-1* in year *t-1*,
$(F_{t-1})/2$ = one-half the full recruitment fishing mortality implemented in year *t-1*, as the commercial fishery itself is the recapture event and the estimate of exploited abundance is assumed to correspond to mean abundance mid-way through the fishery
M = natural mortality.

Natural mortality is assumed constant over time and age, and is set to 0.1 (Johnson and Quinn, 1998).

Vulnerable abundance for age 2, the youngest age-class considered in the commercial fishery, is not incremented as per the above equation but is assumed the same as in the previous year. While this is unrealistic, the low fishery selectivity for this age class means that this assumption has minimal influence on catch level calculations.

Application of the Baranov catch equation with full-recruitment fishing mortality $F = F_{50\%}$ calculated from yield-per-recruit, in conjunction with mean fishery weigh-at-age, has been the historical method for calculating allowable biological catch (ABC):

$$ABC = \sum_{k=1}^{2} \sum_{a=2}^{max(a)} \frac{F\phi_a}{Z_a} N_a(1 - e^{-Z_a}) * wt_a$$

where $w_{t,a}$ = fishery weight-at-age for age *a*, and Z_a = total mortality for age *a*, calculated as the sum of natural mortality *M* and the product of *F* and selectivity-at-age *a*.

Commercial fishery selectivity values were provided by Dana Hanselman (Alaska Fisheries Science Center) from the Gulf of Alaska sablefish stock assessment.

References

Fournier, D.A., H.J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M.N. Maunder, A. Nielsen, and J. Sibert. 2011. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Taylor and Francis Online.

Hanselman, D.H., C.R. Lunsford, and C.J. Rodgveller. 2015. Chapter 3: Assessment of the sablefish stock in Alaska. In: Stock assessment and fishery evaluation report for the groundfish resources of the GOA and BS/AI as projected for 2016. North Pacific Fishery Management Council, 605 W 4th Ave, Suite 306 Anchorage, AK 99501.

Johnson, S. L., and T. J. Quinn II. 1988. Catch-Age Analysis with Auxiliary Information of sablefish in the Gulf of Alaska. Contract report to National Marine Fisheries Service, Auke Bay, Alaska. 79 pp. Center for Fisheries and Ocean Sciences, University of Alaska, Juneau, Alaska.

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Robson, D.S. and H.A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society. 93: 215-216.

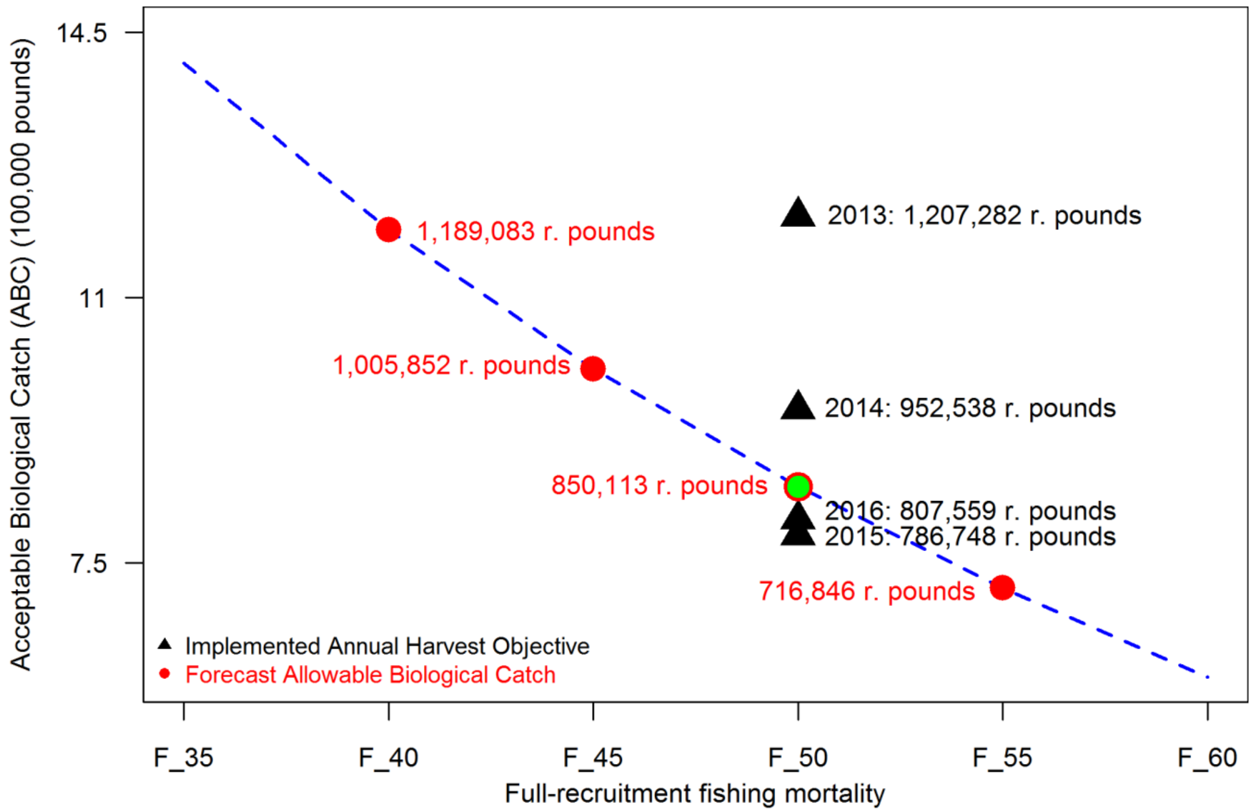

Figure 1. Potential 2017 NSEI commercial longline fishery allowable biological catch (ABC) levels relative to full-recruitment fishing mortality (dashed line), along with historical annual harvest objectives (AHO) implemented at $F_{50\%}$ (triangles) and point estimates of potential ABC levels at $F_{40\%}$ - $F_{55\%}$ (circles)

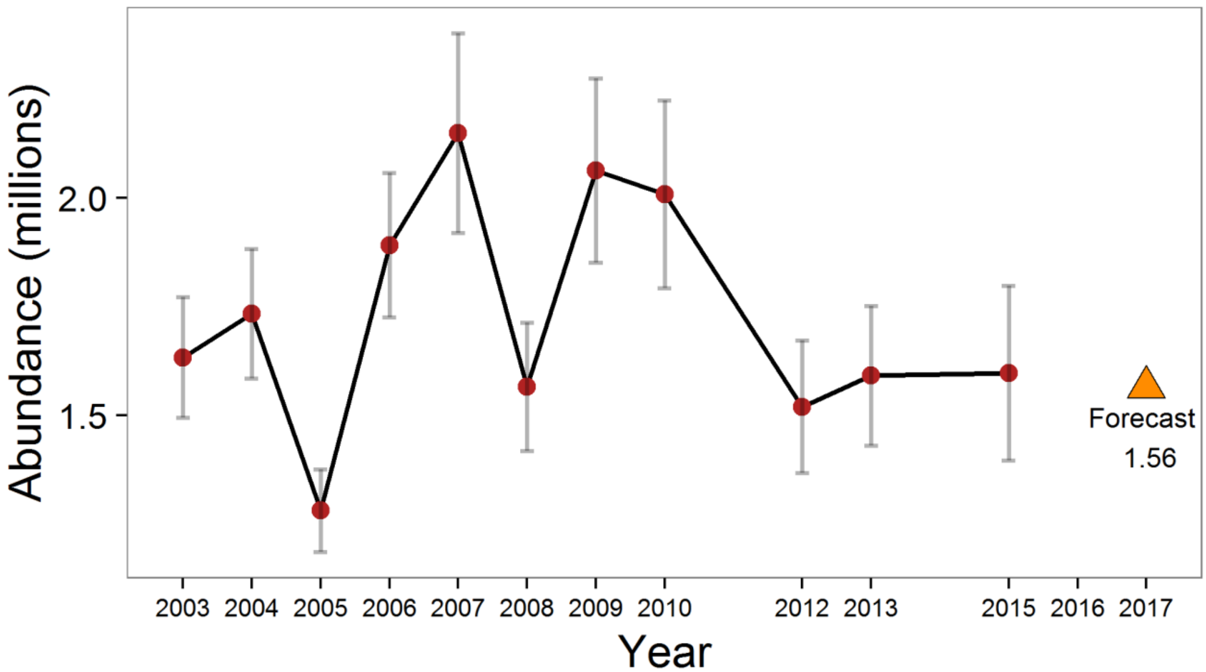

Figure 2. Estimates of total exploitable abundance from the binomial-likelihood Chapman pooled mark-recapture estimator applied to total marks and recoveries with the 2017 forecast (triangle). Vertical bars are 95% confidence intervals.

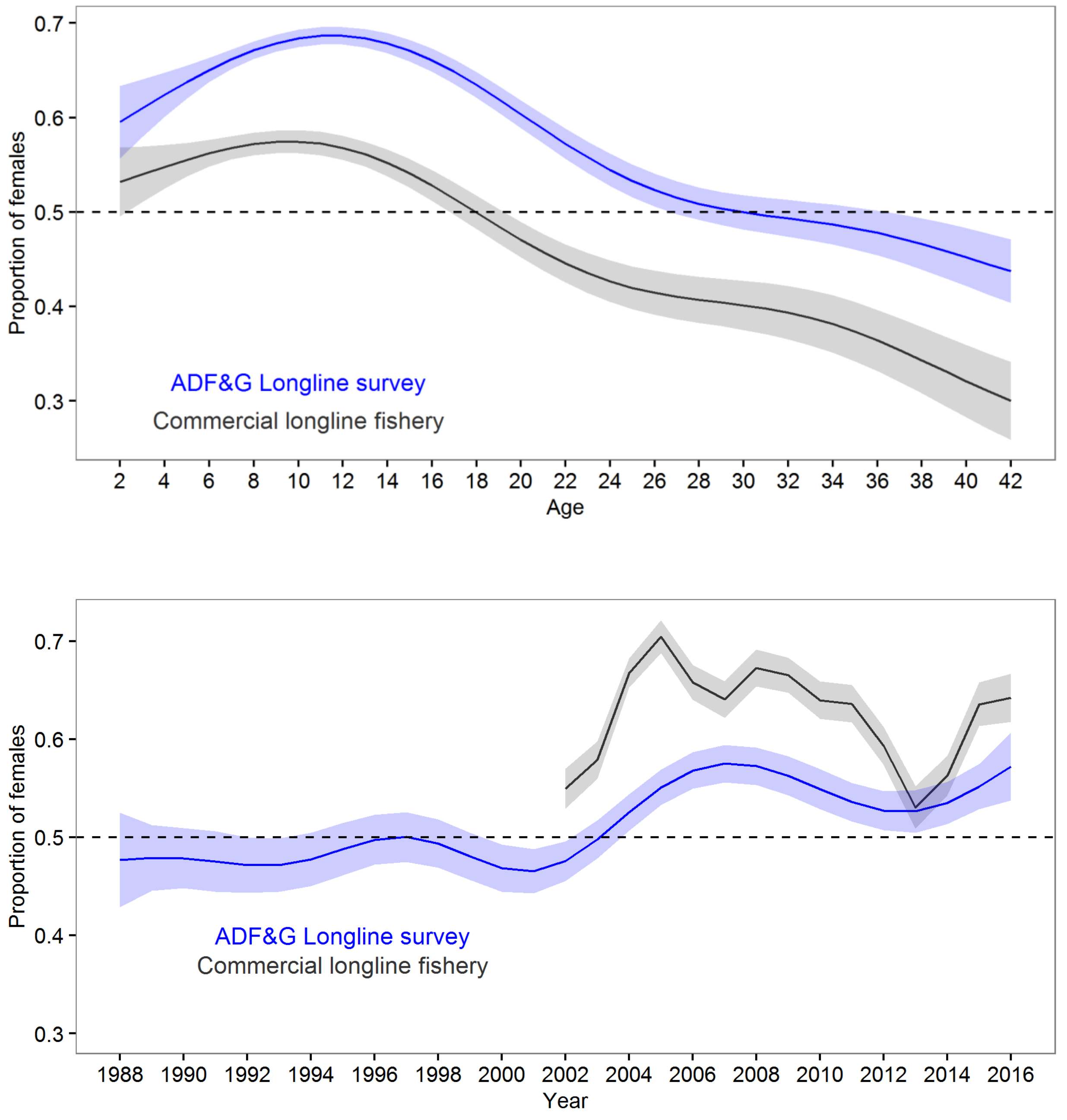

Figure 3. Relative proportion of females by age in the commercial longline fishery catch compared with the ADF&G longline survey, and relative proportions of females by year in the commercial longline fishery catch compared with the ADF&G longline survey.

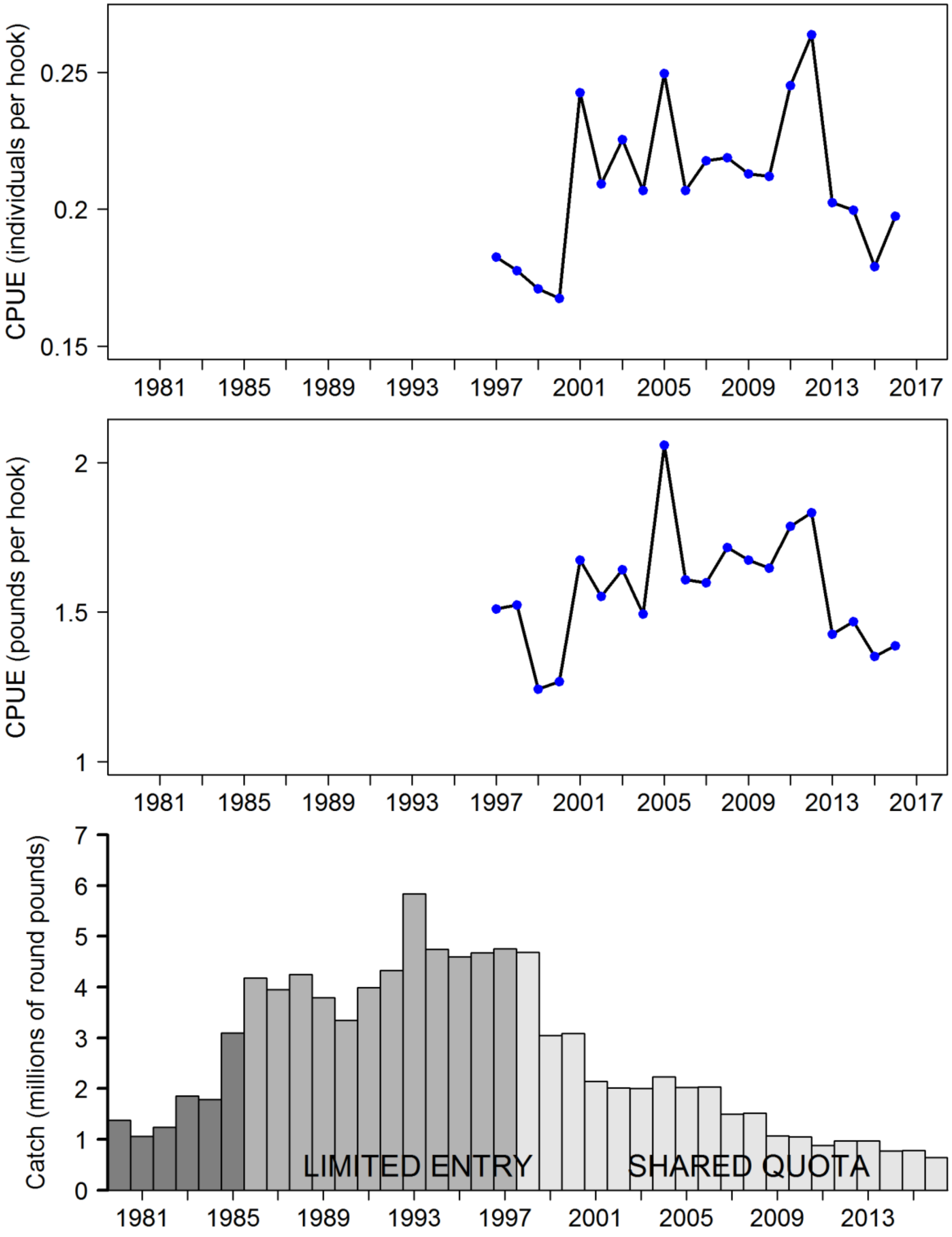

Figure 4. NSEI sablefish longline survey catch-per-unit-effort (CPUE) in individuals-per-hook, CPUE in pounds-per-hook, and commercial catch 1980 - 2016.

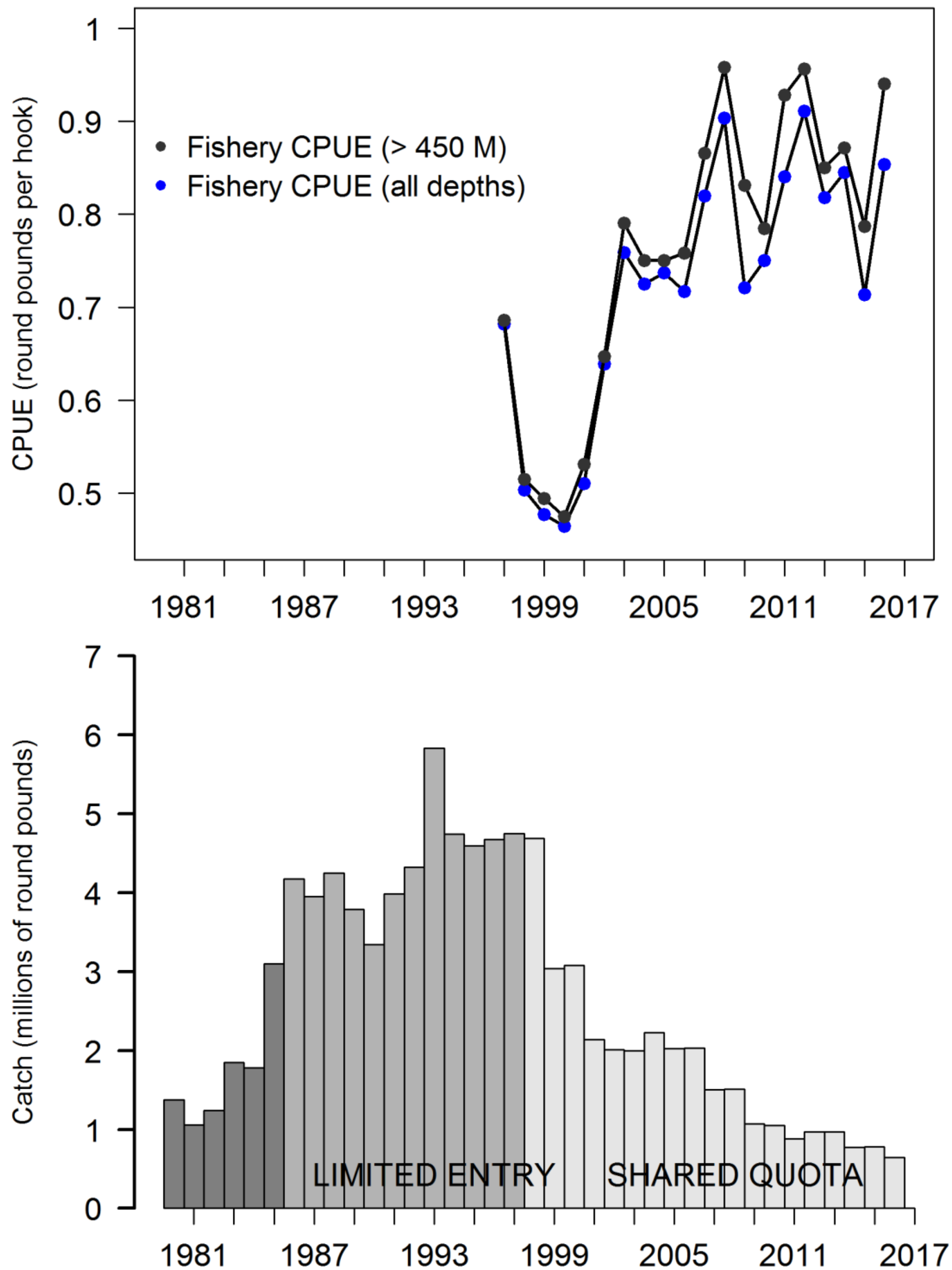

Figure 5. NSEI commercial longline fishery sablefish catch-per-unit-effort (CPUE) in round pounds-per-hook over all fished depths and depth greater than 450 meters from 1997 - 2016, and commercial catch from 1980 - 2016.

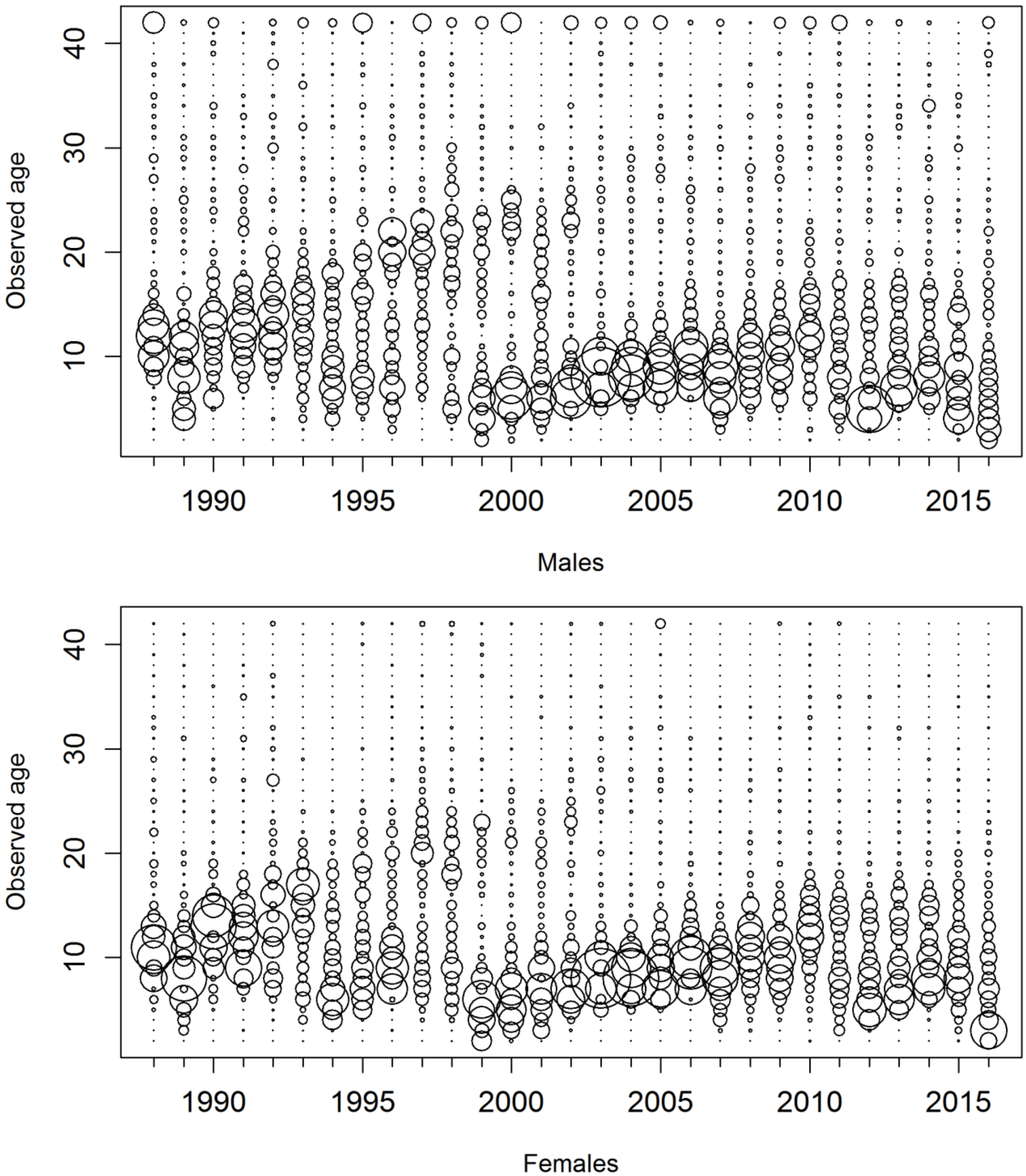

Figure 6. Proportions-at-age for males and females in the ADF&G longline survey, 1988 - 2016.

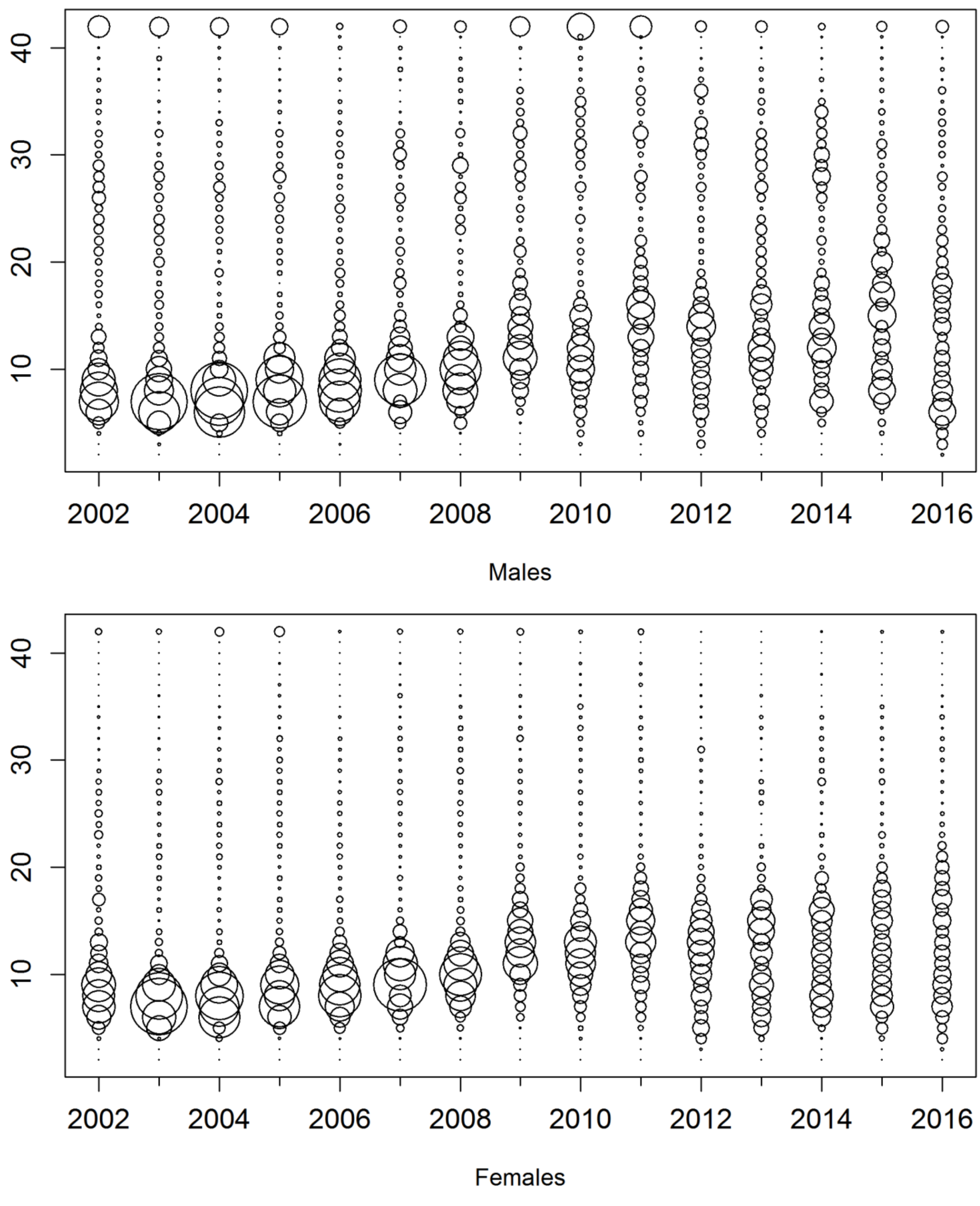

Figure 7. Proportions-at-age for males and females in the commercial longline fishery, 2002 - 2016.

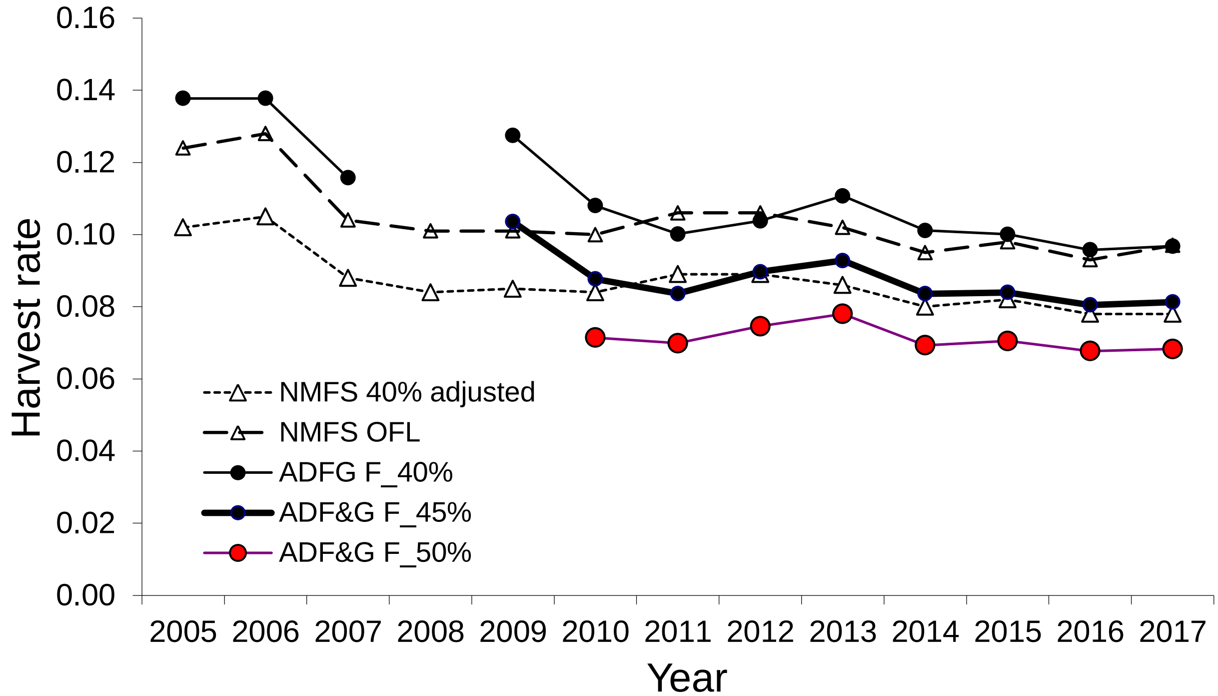

Figure 8. A comparison of sablefish harvest rates among years and between agencies. ADF&G used the F40% harvest rate for calculating the acceptable biological catch (ABC) prior to 2009, the F45% harvest rate in 2009, and the F50% harvest rate since 2010. NOAA has recommended either the F40% adjusted or more conservative harvest rate for the GOA/BSAI fishery, depending on the year. NOAA overfishing definition is Equal to the F35% adjusted harvest rate.