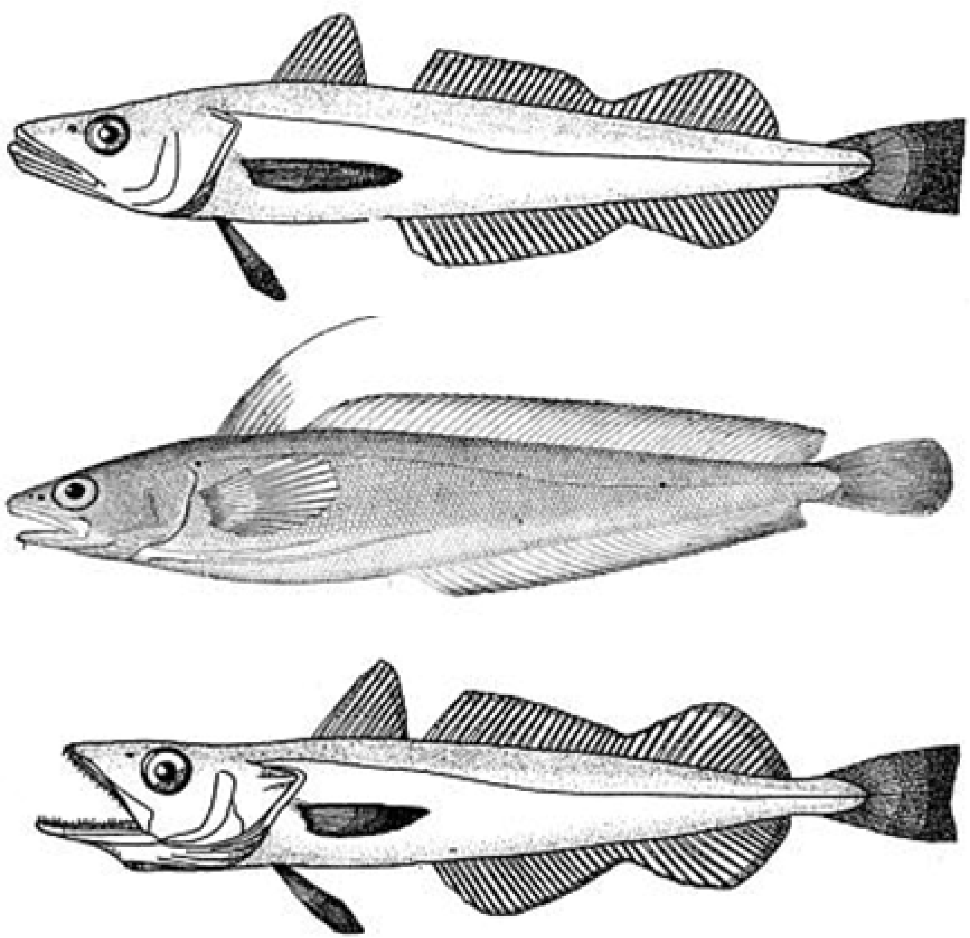
NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Stock Assessment and Fishery Performance Report for Fishing Year 2016

Small-Mesh Multispecies



1.0 Executive Summary

This Stock Assessment and Fishery Evaluation (SAFE) Report was prepared by the New England Fishery Management Council's Whiting Plan Development Team (PDT). The biological and sociological information for New England's small-mesh multispecies complex (silver hake, red hake and offshore hake) are updated in this report.

Each of the small-mesh multispecies stocks is updated according to the current overfishing definitions and most recent trawl survey information. ABC and ACL recommendations are also provided for the 2018-2020 fishing years. The PDT estimated the ABC for both silver hake stocks using the 25th percentile (also known as P*) and both red hake stocks using the 40th percentile. The OFL for northern and southern silver hake are estimated at 58,350 mt and 31,180 mt, respectively. The OFL for northern and southern red hake are estimated at 840 mt and 1,150 mt, respectively. The PDT assessed the performance of the fishery and analyzed and identified current fishery trends.

From fishing years 2015 to 2016, northern red hake catch increased by 19% while landings increased by 60%. Likewise, northern silver hake catch increased by 35% while landings increased by 39%. These increases are consistent with trends in stock biomass and in 2016, the estimated catches did not exceed the ABCs. Southern whiting catch increased by 17% and landings increased by 5%. These amounts were well below their respective specifications, although stock biomass for silver hake has declined. In contrast, southern red hake catch declined by 29% while landings decreased by 24% from 2015 levels. This change is consistent with declines in southern red hake biomass, but were not enough to avert overfishing in 2016 or the stock from becoming overfished. It is important that overfishing occurred despite the 2016 southern red hake catch being below the ABC.

The stock assessment update for calendar year 2016 shows that both stocks of silver hake and also northern red hake are not overfished and overfishing is not occurring. The estimated exploitation rate for southern red hake has however exceeded the threshold and overfishing is thus occurring. In addition, the biomass has declined below the minimum biomass threshold and thus the stock is also considered to be overfished. This is a status change from the previous southern red hake assessment update that was conducted using catch estimates for 2015 and the spring survey biomass for 2016.

An update assessment was performed by the Northeast Fisheries Science Center (NEFSC) and presented to the Whiting PDT in July. This assessment followed the same procedures that were applied in the benchmark assessment using new survey data and catch estimates. Also, scientific uncertainty in these estimates were estimated and the full range of potential ABC values as well as probability of overfishing (ABC>OFL) will be presented to the Scientific and Statistical Committee (SSC). These estimates included the ABC at the 25th percentile for silver hake and the 40th percentile for red hake, separately for the northern and southern management areas.

During the last update assessment and development of three-year specifications, two advisors raised concerns about red hake stock structure and survey availability due to interference with fixed gear. More data and analyses were presented to the SSC, who felt that the concerns were valid but also deemed the assessment was consistent with currently available information. The SSC did however recommend that these issues should be more thoroughly examined at the next benchmark assessment. In addition, it has been six years since the last benchmark assessment and will be nine years old by the next specification cycle. Changes in distribution and an apparent shift in relative productivity of northern and southern stocks may make the existing reference point benchmarks (1973-1982 for silver hake and 1980-2009 for red hake) less suitable for future management targets and thresholds. Further advancements could be made if red hake aging data can be used in the assessment. An alternative assessment could also be performed using survey data ONLY from the RV Bigelow time series, coupled with compatible state survey data (including the ME/NH and NEMAP trawl surveys). The 2011 benchmark assessment adjusted the RV Albatross survey series to RV Bigelow units based on calibration data (which has some level of uncertainty) that the NEFSC collected during the transition.

After reviewing the PDT advice, the SSC felt that the buffers the Council chose for scientific uncertainty were appropriate and had worked as intended during the 2012-2014 specification period. The SSC therefore approved using the 25th percentile for silver hake and a less conservative 40th percentile for red hake. The proposed 2018-2020 specifications are shown in the table below.

Table 1. Proposed 2018-2020 specifications

Stock	OFL (mt)	ABC (mt)	ACL (mt)	Change from 2016-2017	TAL (mt)
Northern silver hake	58,350	31,030	29,475	+33%	26,604
Northern red hake	840	721	685	+2.6%	274
Southern whiting	31,180	19,395	18,425	-37%	14,465
Southern red hake	1,150	1,060	1,007	-2.4%	305

In 2016, an automatic post-season accountability measure (AM) was applied to northern red hake due to overages in 2015. This action reduced the TAL trigger (it triggers a reduction of the possession limit to an incidental 400 lbs.) from 45% of the TAL to 37.9%. During 2016, the catch of northern red hake was below the ACL, however. The PDT has no recommendation about adjusting the northern red hake AM at this time, but any increase would need to be considered through a management action. It may be worthwhile to wait a year to see if the 2016 AM was needed to prevent future overages.

Also, there is no plan or automatic action to rebuild a small-mesh multispecies stock that has become overfished. The Council could choose a more conservative ABC that has less scientific uncertainty or risk of causing overfishing. While this approach can work well for a target species with output controls or other measures that cap fishing effort, an adjustment of specifications by itself may be insufficient for red hake because well over 50% of the catch is discarded in the small-mesh and other fisheries (note the difference between the red hake ACLs and the TALs in the table above). The Council should consider how and when to address this problem when it sets priorities.

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3.0 ABC/ACL Specifications

3.1 Recommendations from the Whiting PDT

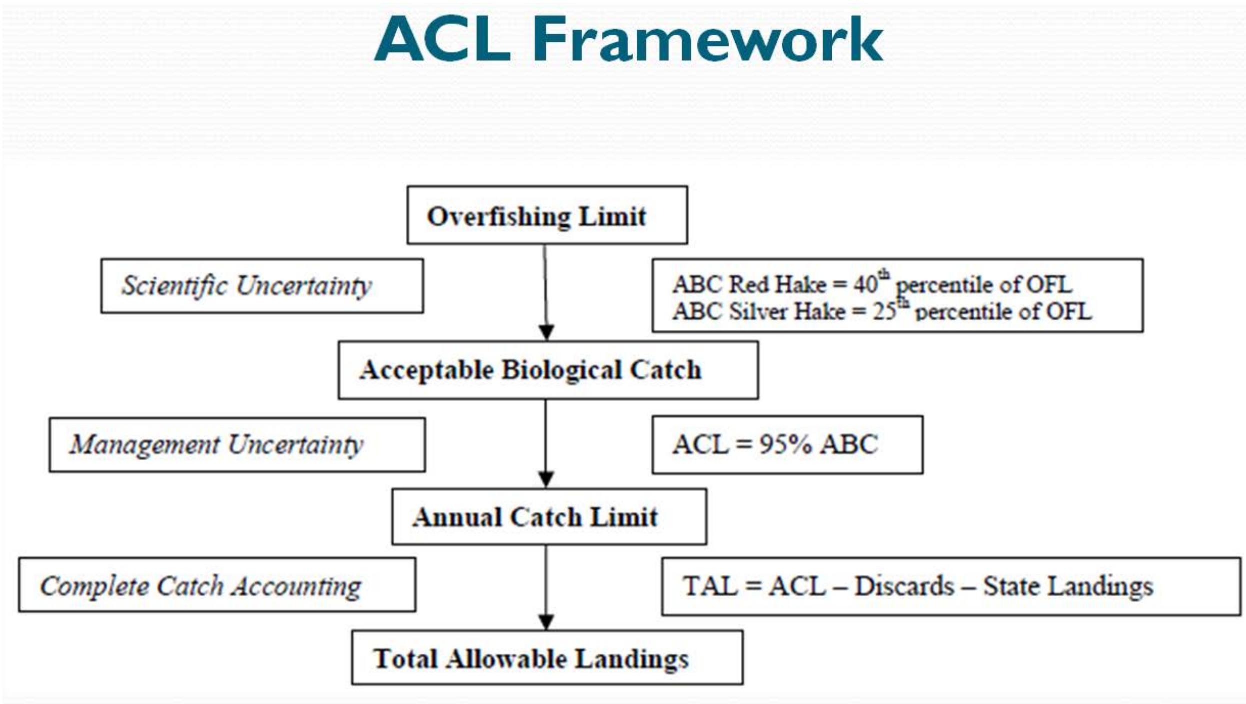
The following recommendations and advice are given to the New England Fishery Management Council's Scientific and Statistical Committee (SSC) for setting the acceptable biological catch (ABC) specifications for the 2018-2020 fishing years. Specifications will be reviewed by the Council at the September 2017 meeting and approved as final at the December 2017 meeting, with the intention of becoming effective on May 1, 2018.

The Whiting PDT makes no recommendations for changing the formulation or basis for setting silver and red hake ABCs, or estimation of the overfishing limits (OFL). The Northeast Fisheries Science Center (NEFSC) prepared an assessment update using the same procedures that were applied to the 2010 Benchmark assessment (http://www.nefsc.noaa.gov/publications/crd/crd1102/index.html), including catch (landings, discards, and transfers-at-sea for bait) data through calendar year 2016. Survey biomass indices were updated through fall 2016 for northern and southern silver hake[1], spring 2017 for northern and southern red hake. As before, the southern silver hake ABC is adjusted by 4 percent to account for the average catches of offshore hake, which are often mixed with silver hake or have often been misreported as landings of silver hake.

Following the previous Council set specifications in Amendment 19 for the 2012-2014 fishing years, the PDT calculated ABCs associated with a range of scientific uncertainty to provide specification advice. Not only were the catch and survey data updated with new information, but the NEFSC updated the estimate of scientific uncertainty to give advice about ABC levels. For Amendment 19, the Council chose to set the silver hake ABC using the 25th percentile on the distribution of scientific uncertainty estimates, which equated to a very low probability of overfishing. This choice was made in part due to the economic and ecological importance of silver hake. For red hake, the Council set the ABC using the 40th percentile on the cumulative frequency distribution of the scientific uncertainty estimates, which was less conservative than the approach used for silver hake, but was still associated with a very low probability of overfishing. The rationale for this choice was the relatively low OFL for northern red hake, the relatively low economic value of red hake coupled with its less important role in the ecosystem, and the potential for the northern red hake catch limits to create a “choke species” that would overly constrain the access to the small-mesh fishery resource. The SSC’s advice to the Council for setting the 2012-2014 ABCs can be found at:
http://www.nefmc.org/tech/Reports/Reports%20to%20Council%202011/Whiting_Hake/SSCrept_Sept2011_Whiting.pdf . It should be noted that the OFL values derived from either the point estimate or the median of the OFL probability distribution are slightly different due the skewness in the distribution of the OFL. For the purpose of this update, the point estimate is reported but if otherwise reported will be noted in the document.

[1] The silver hake assessment is reliant on the fall survey and for setting ABCs because the benchmark assessment deemed it to be the most representative of trends in stock biomass.

Figure 1. Small-mesh fishery specification framework adopted and approved in Amendment 19.



Northern silver hake

The assessment update estimates OFL at 58,345 mt. Using the 25th percentile of scientific uncertainty estimates, the ABC would be 31,030 mt and is estimated to have a near zero probability of overfishing (see table below). This ABC is a 27% increase over the 2015-2017 specification.

Table 2. **Northern silver hake ABC options.** The first column provides the percentile of OFL from the cumulative probability distribution, with the associated catch level in column 2. Column 3 is the ratio of catch at the x percentile of OFL relative to median OFL and column 4compares catch at various percentile of OFL to 2016 catch. The last column shows the probability that the indicated catch (or at the ABC) would cause overfishing, accounting for the estimated scientific uncertainty. The yellow row represents the proposed 2018-2020 ABC based on the adopted approach for ABC specification.

Scientific Uncertainty Percentile OFL	Catch (000's mt)	% of OFL Distribution (58.35 kt)	% of 2016-2017 FY Catch	Probability of Overfishing (F > $FMSY_{Proxy}$)
5	12.73	22%	372%	0%
10	17.67	30%	517%	0%
20	26.56	46%	777%	0%
25	**31.03**	**53%**	**908%**	**0%**
30	35.69	61%	1044%	0%
40	45.95	79%	1344%	0%
45	51.81	89%	1515%	17%
50	**58.35**	**100%**	**1707%**	**75%**

Southern silver hake

The update assessment estimates OFL at 37,108 mt. Using the 25th percentile of scientific uncertainty estimates, the ABC would be 20,171 mt and is estimated to have a near zero probability of overfishing. This ABC is a 38% decrease compared to the 2015-2017 specification. The 20,171 mt ABC estimate in the update assessment accounts for an average of 4% allocation of offshore hake catch according to previous analysis of species composition in the benchmark assessment and regulations adopted in the 2011 benchmark assessment (NEFSC 2011) and Amendment 19 (NEFMC 2012).

Table 3. **Southern silver hake ABC options**. The first column provides the percentile of OFL from the cumulative probability distribution, with the associated catch level in column 2. Column 3 is the ratio of catch at the x percentile of OFL relative to median OFL and column 4compares catch at various percentile of OFL to 2016 catch. The last column shows the probability that the indicated catch (or at the ABC) would cause overfishing, accounting for the estimated scientific uncertainty. The yellow row represents the proposed 2018-2020. ABC based on the adopted approach for ABC specification.

Scientific Uncertainty Percentile OFL	Catch (000's mt)	% of OFL Distribution (58.35 kt)	% of 2016-2017 FY Catch	Probability of Overfishing ($F > FMSY_{Proxy}$)
5	7.74	21%	201%	0%
10	10.84	29%	282%	0%
20	16.55	45%	431%	0%
25	**20.17**	**54%**	**525%**	**0%**
30	22.45	60%	584%	0%
40	29.14	79%	758%	7%
45	32.91	89%	856%	26%
50	**37.11**	**100%**	**966%**	**59%**

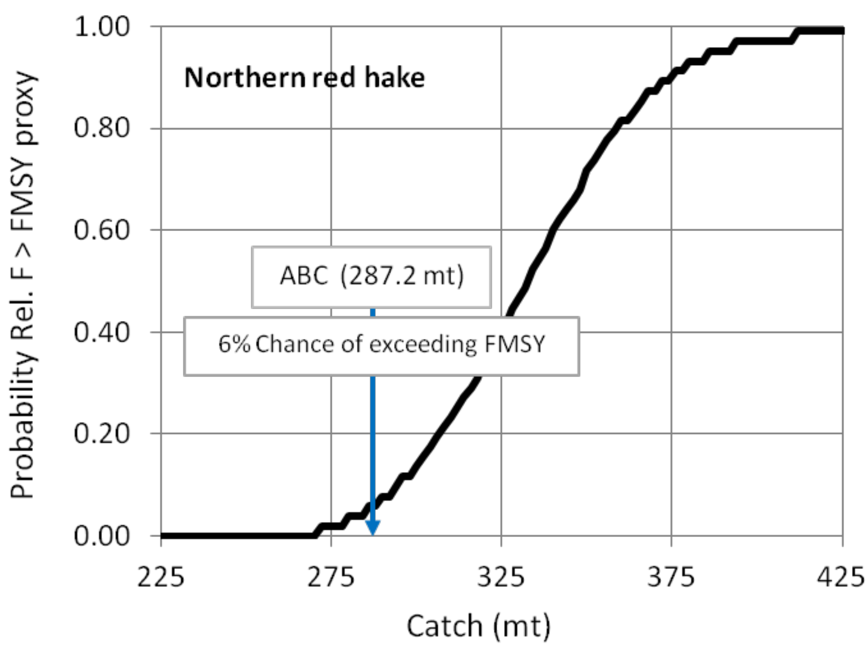
Northern red hake

The assessment update estimates OFL at 807 mt. Using the 40th percentile of scientific uncertainty estimates, the ABC would be 720 mt and is estimated to have a 10% probability of overfishing (see table below). This ABC is a 45% increase compared to the 2015-2017 specification owing to the increase in the survey biomass in recent years. However, with recent increases in catches (attributed mostly to discards), the ABC is approximately 89% of the OFL resulting in slightly higher risk of exceeding overfishing limit

Table 4. **Northern red hake ABC options**. The first column provides the percentile of OFL from the cumulative probability distribution, with the associated catch level in column 2. Column 3 is the ratio of catch at the x percentile of OFL relative to median OFL (point estimate) and column 4compares catch at various percentile of OFL to 2013 catch. The last column shows the probability that the indicated catch (or at the ABC) would cause overfishing, accounting for the estimated scientific uncertainty. The yellow row represents the proposed 2015-2017 ABC based on the adopted approach for ABC specification

Scientific Uncertainty Percentile OFL	Catch (000's mt)	% of OFL Distribution (58.35 kt)	% of 2016-2017 FY Catch	Probability of Overfishing ($F > FMSY_{Proxy}$)
5	0.192	24%	47%	0%
10	0.343	42%	85%	0%
20	0.510	63%	126%	0%
25	0.571	71%	141%	0%
30	0.625	77%	154%	0%
40	0.720	89%	178%	10%
45	0.764	95%	189%	21%
50	0.807	100%	199%	37%

Figure 2. Risk of exceeding F_{MSY} for northern red hake. (Update figure???)



Southern red hake:

For southern red hake, the assessment update estimates OFL at 1,122 mt. Using the 40th percentile of scientific uncertainty estimates, the ABC would be 1,064 mt and is estimated to have a 23 percent probability of overfishing (see table below). This ABC is an 38% decrease compared to the 2015-2017 specification. The decrease in ABC can be attributed to continued decline in the survey biomass with catches fairly stable in the recent five years

Table 5. **Southern red hake ABC options**. The first column provides the percentile of OFL from the cumulative probability distribution, with the associated catch level in column 2. Column 3 is the ratio of catch at the x percentile of OFL relative to median OFL and column 4compares catch at various percentile of OFL to 2016 catch. The last column shows the probability that the indicated catch (or at the ABC) would cause overfishing, accounting for the estimated scientific uncertainty. The yellow row represents the proposed 2018-2020 ABC based on the adopted approach for ABC specification

Scientific Uncertainty Percentile OFL	Catch (000's mt)	% of OFL Distribution (58.35 kt)	% of 2016-2017 FY Catch	Probability of Overfishing (F > $FMSY_{Proxy}$)
5	0.75	66%	68%	0%
10	0.83	74%	76%	0%
20	0.93	83%	86%	4%
25	0.97	86%	89%	8%
30	1.00	89%	92%	12%
40	**1.06**	**94%**	**97%**	**23%**
45	1.09	97%	100%	31%
50	**1.12**	**100%**	**103%**	**39%**

Figure 3. Risk of exceeding F_{msy} for southern red hake. (**Update figure**)

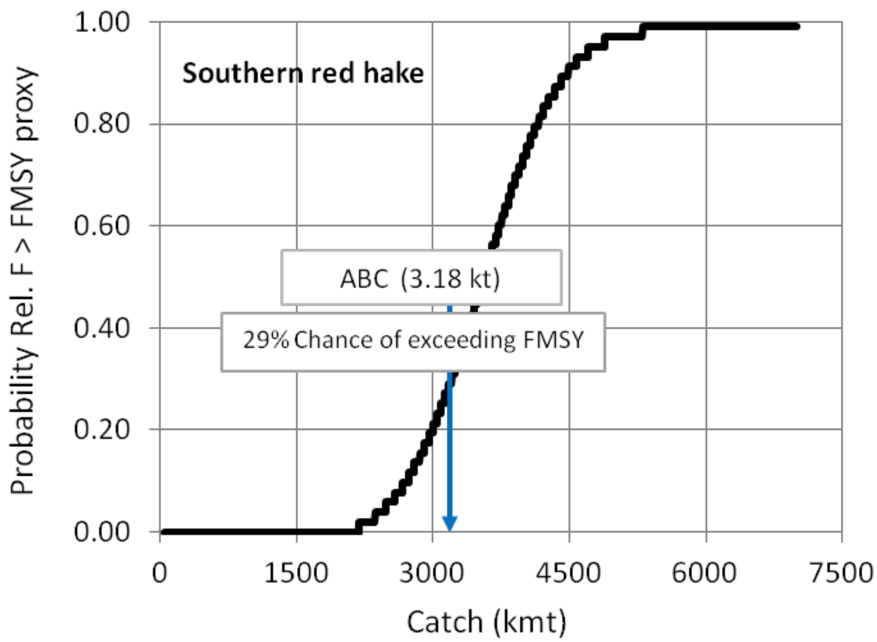


Table 6. Summary of 2018-2020 ABC specification and OFL estimates for small mesh multispecies, adjusted for catches of offshore hake. OFL values are based on the point estimate and not the median from the OFL probability distribution. Lower values of southern red hake ABC having less risk of overfishing are provided below the line.

	OFL (mt)	ABC (mt) @ P*	P(>OFL)	Change in ABC compared to 2015-2017
Northern silver hake	58,350	31,030 @ 25^{th} percentile	< 1%	27% increase
Southern whiting	37,108	20,171 @ 25^{th} percentile	< 1%	38% decrease
Northern red hake	807	720 @ 40^{th} percentile	10%	45% increase
Southern red hake	1,122	1,064 40^{th} percentile	23%	38% decrease
Southern red hake	1,122	1,000 30^{th} percentile	12%	42% decrease
Southern red hake	1,122	930 20^{th} percentile	4%	46% decrease

3.2 Scientific and Statistical Committee Specification Approval

To be completed after the October 2017 SSC meeting ???

4.0 Advisory Panel Discussion

To be completed at the Aug 29 2017 meeting ????

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5.0 Management Background

The small-mesh multispecies fishery consists of three species: Silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), and offshore hake (*Merluccius albidus*). There are two stocks of silver hake (northern and southern), two stocks of red hake (northern and southern), and one stock of offshore hake, which primarily co-occurs with the southern stock of silver hake. There is little to no separation of silver and offshore species in the market, and both are generally sold under the name “whiting.” Throughout the document, “whiting” is used to refer to silver hake and offshore and silver hake combined catches.

Collectively, the small-mesh multispecies fishery is managed under a series of exemptions from the Northeast Multispecies Fishery Management Plan. The Northeast Multispecies FMP requires that a fishery can routinely catch less than 5% of regulated multispecies to be exempted from the minimum mesh size. In the Gulf of Maine and Georges Bank Regulated Mesh Areas (Figure 4), there are six exemption areas, which are open seasonally (Table 7).

Table 7. Northern area exemption program seasons

	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Cultivator		June 15 – October 31										
GOM* Grate			July 1 – November 30									
Small I			July 15 – November 30									
Small II	– June 30								January 1 –			
Cape Cod RFT†					Sept 1 – Nov 20							
					September 1 – December 31							

* GOM = Gulf of Maine
† RFT = Raised Footrope Trawl

The Gulf of Maine Grate Raised Footrope area is open from July 1 through November 30 of each year and requires the use of an excluder grate on a raised footrope trawl with a minimum mesh size of 2.5 inches. Small Mesh Areas I and II are open from July 15 through November 15, and January 1 through June 30, respectively. A raised footrope trawl is required in Small Mesh Areas I and II, and the trip limits are mesh size dependent. Cultivator Shoal Exemption Area is open from June 15 – October 31, and requires a minimum mesh size of 3 inches. The Raised Footrope Trawl Exemption Areas are open from September 1 through November 20, with the eastern portion remaining open until December 31. A raised footrope trawl, with a minimum mesh size of 2.5-inch square or diamond mesh, is required. The Southern New England and Mid-Atlantic Regulated Mesh Areas are open year-round and have mesh size dependent possession limits for the small-mesh multispecies.

The mesh size dependent possession limits (Table 8) for all the areas with that requirement are:

Table 8. Mesh size dependent possession limits

Codend Mesh Size	Silver and offshore hake, combined, possession limit	Red Hake
Smaller than 2.5”	3,500 lb	5,000 lb
Larger than 2.5”, but smaller than 3.0”	7,500 lb	5,000 lb
Equal to or greater than 3.0”	30,000 lb (40,000 lb in Southern Area)	5,000 lb

The exemption areas were implemented as part of several different amendments and framework adjustments to the Northeast Multispecies FMP (**Error! Reference source not found.**). In 1991, Amendment 4 incorporated silver and red hake and established an experimental fishery on Cultivator Shoal. Framework Adjustment 6 (1994) was intended to reduce the catch of juvenile whiting by changing the minimum mesh size from 2.5 inches to 3 inches. Small Mesh Areas I and II, off the coast of New Hampshire, were established in Framework Adjustment 9 (1995). The New England Fishery Management Council (Council) established essential fish habitat (EFH) designations and added offshore hake to the plan in Amendment 12 (2000). Also in Amendment 12, the Council proposed to establish limited entry into the small-mesh fishery. However, that measure was disapproved by the Secretary of Commerce because it did not comply with National Standard 4[2] as a result of measures that benefited participants in the Cultivator Shoal experimental fishery and because of the "sunset" provision that would have ended the limited entry program at some date. The Raised Footrope Trawl Area off of Cape Cod was established in Framework Adjustment 35 (2000). A modification to Framework Adjustment 35 in 2002 adjusted the boundary along the eastern side of Cape Cod and extended the season to December 31 in the new area. Framework Adjustment 37 modified and streamlined some of the varying management measures to increase consistency across the exemption areas. In 2003, Framework Adjustment 38 established the Grate Raised Footrope Exemption Area in the inshore Gulf of Maine area.

The Northeast Multispecies FMP was implemented primarily to manage the commercial cod and haddock fisheries in the Gulf of Maine and Georges Bank[3]. The FMP is complicated and has been changed numerous times since 1985 (almost 20 Council amendments and over 50 framework adjustments; not including dozens of emergency, interim, and Secretarial amendments implemented outside of the Council process.) A few of those amendments and several framework adjustments have addressed the small-mesh fishery specifically and are described below.

Amendment 1 (1987) reduced the spatial footprint of the winter inshore whiting fishery in order to protect struggling large mesh species like redfish, gray sole, and dabs; focused the small-mesh target species to large-mesh species ratio on a selected set of species; and reduced the size of the Georges Bank whiting fishery area to protect yellowtail flounder.

Amendment 2 (1989) made some additional, minor changes to the exempted fishery program for whiting and other small-mesh stocks.

Amendment 4 (1991) established the Cultivator Shoals Exemption Area and formally incorporated silver hake and red hake into the FMP. This amendment also established a minimum mesh size for the directed small-mesh fishery as well. This was intended to control mortality of whiting and red hake in this fishery.

Amendment 5 (1994) established an overfishing definition for red hake, and implemented some other minor modifications to small-mesh management, including a standardized bycatch amount of 500 lb of large-mesh groundfish.

[2] National Standard 4 states that measures "shall not discriminate between residents of different States," and that fishing privileges must be "fair and equitable to all such fishermen."

[3] The large-mesh species (cod, haddock, pollock, flounders, etc.) were commonly referred to as the "regulated" species because they were the focus of management originally. That term is confusing as almost all of the commercially viable stocks are now "regulated." This document refers to the management of those species as the "groundfish fishery" or the "large-mesh multispecies fishery."

Framework Adjustment 3 (1994) modified the 500-lb bycatch limit to reduce the incentive for vessels to target groundfish with small mesh. This action changed the limit to "10-percent of the total weight of fish on board, or 500 lb, whichever is less." This preserved the Council's original intent of minimizing mortality on juvenile groundfish, while allowing the legitimate small-mesh fishery to continue.

Framework Adjustment 6 (1994) was intended, in part, to reduce juvenile whiting mortality in the Cultivator Shoals whiting fishery and modified the requirements of that program.

Framework Adjustment 9 (1995) established Small Mesh Areas I and II in the Gulf of Maine and implemented the requirements for fishing in those areas.

An **Adjustment to Amendment 7** (1996) made some minor modifications to non-groundfish bycatch limits in the Cultivator Shoals fishery.

Amendment 12 (1999/2000) addressed a number of small-mesh issues. This amendment officially incorporated offshore hake into the FMP; established essential fish habitat designations for all three small-mesh species; standardized the mesh-size based possession limits (see below); required a Letter of Authorization for several small-mesh exemption areas; and established a provision to allow the transfer of up to 500 lb of small-mesh multispecies at sea. Amendment 12 also proposed a limited access permit program for this fishery. However, that program was not implemented because NMFS determined that it did not comply with the requirement to treat residents of different states equally (National Standard 4.)

Framework Adjustment 35 (2000) established the Raised Footrope Trawl Exemption Area off Cape Cod. A **Modification to Framework 35** (2002) modified the boundaries and seasons of the Cape Cod exemption areas.

Framework Adjustment 37 (2003) eliminated some of the now unnecessary provisions from Amendment 12, clarified the transfer-at-sea provisions, and reinstated the full season (back to an October 31 end date) for the Cultivator Shoal Exempted Fishery. This framework also standardized the types and amounts of incidental species that could be retained in the small-mesh exemption areas between Small Mesh Areas I and II and the Cape Cod Exemption Area.

A new **Control Date** (2003) was formally established with the intentions of developing a limited access permit program.

Framework Adjustment 38 (2003) established the Inshore Gulf of Maine Grate Raised Footrope Trawl Exemption Area along the coast of Maine.

A **Secretarial Amendment** (2012) brought this portion of the FMP into compliance with the Magnuson-Stevens Act requirements to have (1) annual catch limits and (2) measures to ensure accountability for each Council managed fishery. A Secretarial Amendment was necessary because the development of Amendment 19, the mechanism through which the Council was intending to adopt the new requirements, was delayed.

The **control date** for the small-mesh multispecies was modified to November 28, 2012.

Amendment 19 (2013) allowed the Council to incorporate updated stock assessment information and adopt the annual catch limit structure implemented in the 2012 Secretarial Amendment. Amendment 19 modified the accountability measures, adopted new biological reference points, and established a trip limit for red hake.

Framework Adjustment 50 (2013) established a separate, sub-annual catch limit of Georges Bank yellowtail flounder for the small-mesh fishery (whiting and squid fisheries.)

Framework Adjustment 51 (2014) implemented accountability measures for that sub-annual catch limit.

Post-season Accountability Measure (2015) reduced the TAL trigger for northern red hake from 90% of the TAL to 62.5% of the TAL.

Specifications for 2015-2017 (2016) adjusted the OFL, ABC. ACL, and TALs to account for changes in stock biomass. The specification document also changed the northern red hake possession limit to 3,000 lbs. at the beginning of the fishing year, which would automatically drop to 1,500 lbs. when landings reach 62.5% of the TAL. Due to prior overages, the TAL trigger was reduced to 45% of the TAL.

Post-season Accountability Measure (2016) reduced the northern red hake TAL trigger from 45% of the TAL to 37.9%.

The following figure summarizes the past, current, and proposed specifications by stock. ???

Figure 4. Annual specifications and catch estimates for small-mesh multispecies by stock

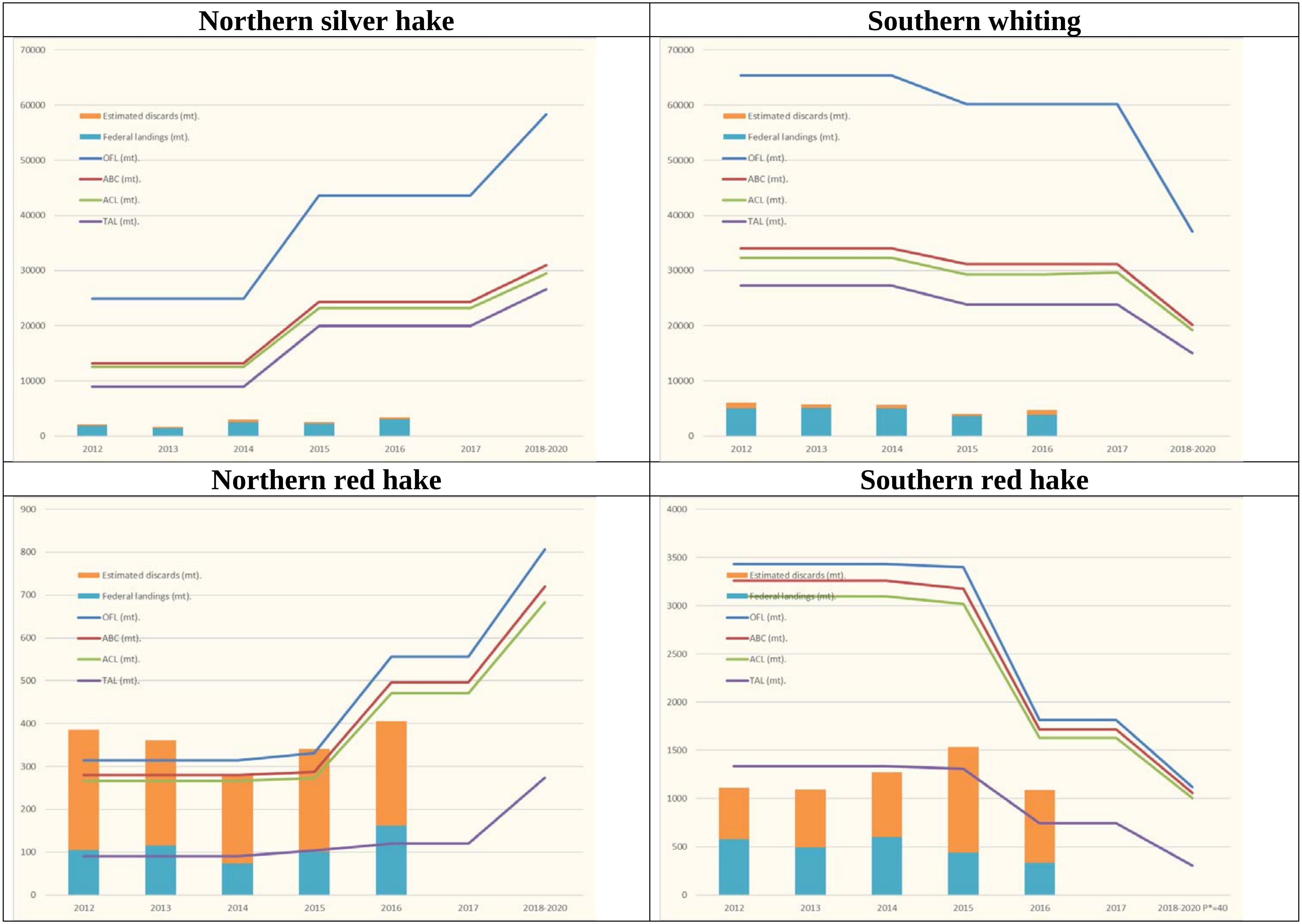
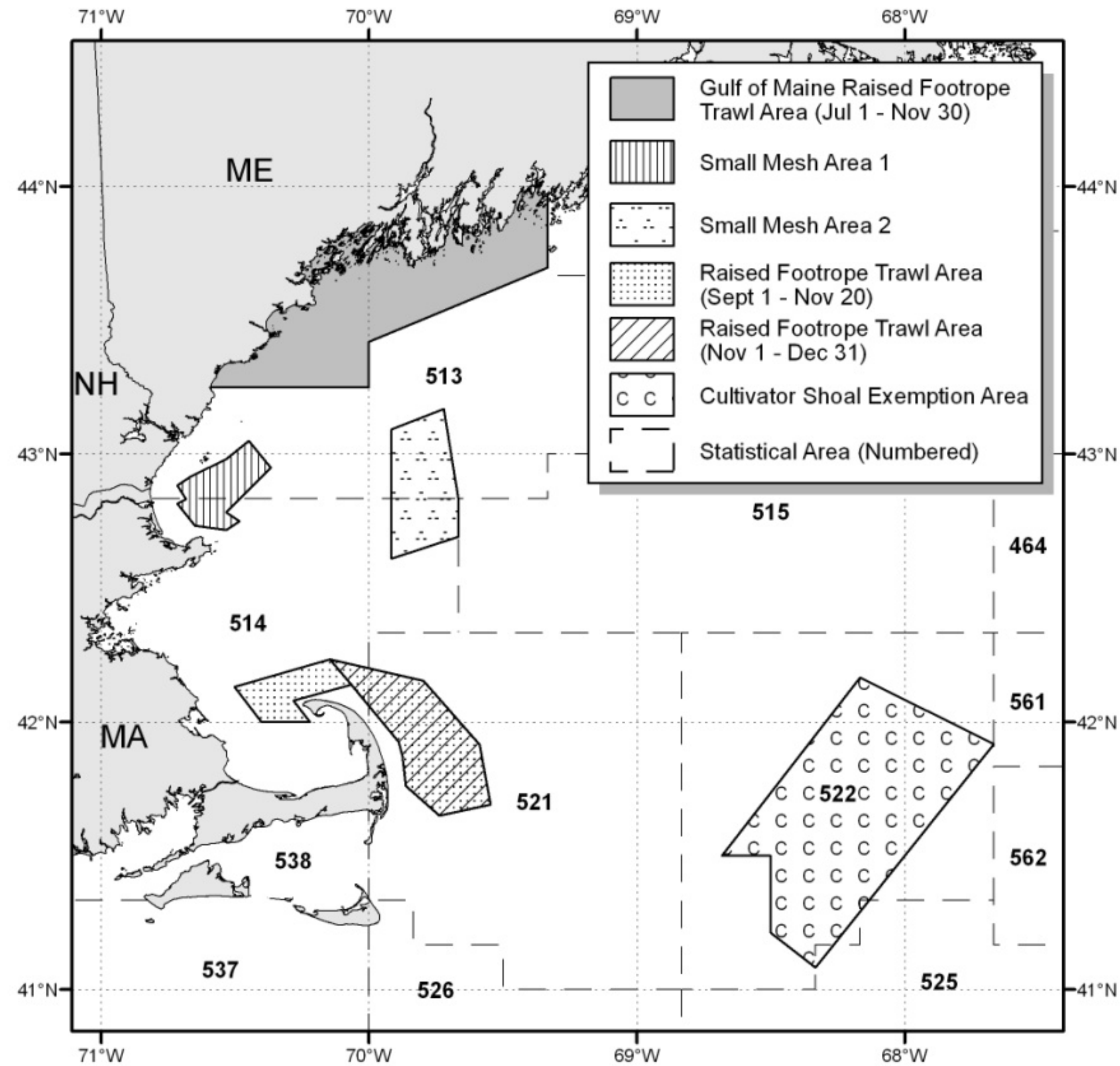


Figure 5. Small-mesh exemption areas in the Gulf of Maine and Georges Bank



Vessels participating in any of the exemption areas must have a Northeast Multispecies limited access or open access category K permit and must have a letter of authorization from the Regional Administrator to fish in Cultivator Shoal and the Cape Cod Raised Footrope areas. Most of the areas (Small Mesh Areas I and II, the Cape Cod Raised Footrope areas, Southern New England Exemption Area, and the Mid-Atlantic Exemption Area) have mesh size dependent possession limits for silver and offshore hake, combined (Table 8). The Gulf of Maine Grate Raised Footrope Area has a possession limit of 7,500 lb, with a 2.5-inch minimum mesh size, and Cultivator Shoal has a possession limit of 30,000 lb, with a 3-inch minimum mesh size.

The red hake possession limit is 5,000 lb, regardless of area fished. Amendment 19 also implemented a 40,000 lb possession limit for vessels fishing in the southern stock area.

6.0 Fishery Performance Report

6.1 Annual Catch Limit Accounting

Annual catch limits were implemented for the small-mesh fishery, via Secretarial Amendment, on May 1, 2012, and adopted by the Council through Amendment 19 to the Northeast Multispecies FMP later that year. These catch limits were implemented for fishing years 2012 through 2014, then revised in 2015 via a specifications package. The red hake specifications were again adjusted in 2016 to react to confirmation of a very large 2013 year-class. This report contains complete catch accounting information for fishing years 2012 and 2013 (Table 10 and Table 11), as the 2014 fishing year is ongoing. The annual catch limit was derived using the procedure described in Figure 1. The specifications are listed in Table 9.

Table 9. Fishing year 2016-2017 specifications and estimated catch.

Specification	Stock Northern red hake	Northern silver hake	Southern red hake	Southern whiting
OFL (mt).	556	43,608	1,816	60,148
ABC (mt).	496	24,383	1,717	31,180
ACL (mt).	471	23,161	1,631	29,261
Estimated discards (mt).	243	322	760	824
State-Water Landings (mt, 3% of ACL).	14	695	49	878
Federal TAL (mt).	120	19,949	746	23,833
Federal TAL (lbs.)	264,555	43,980,004	1,644,648	52,542,756
TAL trigger (%).	45.0%	90.0%	90.0%	90.0%
TAL trigger (lbs.)	119,050	39,582,004	1,480,183	47,288,481

* Southern whiting specifications include a 4% increase from those for southern silver hake to account for mixed catches of offshore hake.

The Secretarial Amendment implemented, and Amendment 19 modified, accountability measures for the small mesh fishery. There are both in-season and post-season accountability measures for this fishery. The in-season accountability measure is a reduction in the trip limit to a lower level or to the incidental level when a specified percentage of the total allowable landings limit has been landed. During the fishing year, if landings have exceeded the trigger percentage of the total allowable landings (TAL), NMFS will then reduce the possession limit for the remainder of the fishing year. Under the current Plan, the possession limits for southern red hake, norther silver hake and southern silver hake are reduced to the incidental level when 90 percent of the TAL is reached. For northern red hake, two trigger points are established that lower possession limits to constrain catch: A reduction in the possession limit to 1,500 lbs when 45 percent of the TAL is reached; and a reduction to the incidental catch limit of 400 lbs. when 62.5 percent of the TAL is harvested. Because the northern red hake catch exceeded the ACL in 2015, the initial possession limit for 2017 is 3,000 lbs., but declines to 400 lbs. when northern red hake landings exceed the trigger.

The post-season accountability measure takes effect when a small-mesh multispecies stock exceeds the annual catch limit (ACL) in a given fishing year, requiring the in-season accountability measure (incidental trigger percentage) to be reduced on a percentage basis from the existing trigger percentage. The reduction in catch earlier in the season is intended to extend the fishery and avoid overages in subsequent fishing years.

In fishing year 2012, the incidental possession limit trigger was 90 percent for all four stocks small-mesh multispecies stocks. Because the northern red hake ACL was exceeded by 45 percent, the incidental possession limit trigger was reduced from 90 percent to 45 percent. However, due to an error in the specifications for 2012-1014, the possession limit reduction trigger point for reducing the possession limit for northern red hake to 400 lb was adjusted from 45 percent to 62.5 percent of the TAL. Future accountability measures for fishing years in which the catch exceeds the ACL will be deduced from the corrected 62.5-percent trigger.
This change was included in the final specifications packages for the 2015-2017 fishing years. That action also reduced the northern red hake possession limit from 5,000 lb to 3,000 lb to delay the in-season accountability measure until later in the season and restrict the chance of an ACL overage, as occurred in fishing years 2012 and 2013. Additionally, it established a new in-season possession limit trigger point that will reduce possession limits for northern red hake to 1,500 lb when estimated landings reach 45 percent of the TAL.

In FY 2015 the northern red hake ACL was 273 mt, with a TAL of 104.2 mt. Northern red hake catch, including landings and discards, was 340 mt which exceeded the ACL by 24.6 percent. Consequently, the regulations require that the possession limit trigger be reduced from 62.5 percent of the TAL to 37.9 percent of the TAL. If implemented for the 2017 fishing year which begins on May 1, 2017, the possession limit for northern red hake will be reduced from 3,000 lbs to 400 lbs once 37.9 percent of the TAL is landed. The reduced trigger would remain in effect until the New England Fishery Management Council changes it through specifications or a framework action.

NMFS published specifications for the small mesh multispecies fishery for 2015-2017 on May 28, 2015, based on stock assessment updates using data through 2014. The Northeast Fisheries Science Center completed a stock assessment update in 2015, using survey data through 2015. The 2015 update revealed that the northern red hake stock is increasing in biomass, while the southern red hake stock biomass is decreasing. In light of this updated assessment, NMFS modified the northern and southern red hake specifications for 2016-2017 in a final rule published in June 2016. That action increased the TAL and catch limits for northern red hake and decreased the TAL and catch limits for southern red hake.

Despite the increase in the TAL and catch limits for northern red hake, the 2016 fishery met the possession limit trigger of 62.5 percent of the TAL on August 16, 2016, resulting in the reduction of possession limits to 400 lbs, however; the fishery is not expected to exceed the ACL in FY 2016 because it was increased to a level (471 mt) that greatly exceeds the catch levels previously reached. Regardless, the Council is charged with determining a way forward with respect to the 2015 overage.

Scenarios

1. Consistent with the regulations at 648.90(b)(5)(ii), *post season adjustment for an overage*, NMFS could reduce the possession limit trigger, which would restrict the fishery to incidental levels once 37.9 percent of the TAL is harvested. Currently, the fishery is not restricted to incidental levels until 62.5 percent of the landings are reached. The change to a 37.9-ercent trigger will prolong fishery through reduced landings and incentivize fishermen to avoid red hake discards which count toward the ACL. However, it could inhibit the catch of northern silver hake, a stock that is not fully utilized and catch has remained well below the established limits. The Council will need to determine whether the trigger percentage should be changed through a framework action.
2. The Council may choose to maintain the incidental trigger percentage at 62.5-percent given the recent increase in northern red hake catch limits. Although the fishery met the trigger in 2016 relatively early in the season, the incidental landing limits will constrain catch to reduce the chance of an ACL overage and if the trigger percentage remains the same, it may help reduce red hake discards in the northern silver hake fishery and allow for more optimization of the silver hake resource which has its catch constrained by red hake possession limits.
3. The Council could wait to see how the current fishing year (2016) finalizes. If landings are adequately constrained through the current triggers, then there may be less desire to further restrict the fishery given that the higher ACLs are unlikely to be exceeded.

Questions

Is NMFS obligated/required to drop the trigger? If so, how long does it remain effective? Until the Council takes action? Regs say that NMFS shall reduce the percentage in a subsequent fishing year but unlikely without Council recommendation to do so (a framework).

Would restricting catch to the incidental default early in the season be too restrictive on the fishery and is it necessary if the ACL is not expected to be exceeded? Also, couldn't it result in excessive discards if vessels are unable to avoid NRH which has an increase in Biomass?

Table 10. Fishing year 2016 northern and southern red hake landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (471 mt)	Percent of Total Catch	Percent Change from prior fishing year
Northern red hake commercial landings	357,005	162	34%	40%	60%
Northern red hake state-permitted only vessel landings	0	0	0%	0%	
Northern red hake estimated discard	535,118	243	52%	60%	2%
Northern red hake recreational landings (MRIP)	6,210	3	1%	1%	43%
Northern red hake catch*	892,123	405	**86%**	100%	19%
	Pounds	**Metric tons**	**Percent of ACL (1,631 mt)**	**Percent of Total Catch**	**Percent Change from prior fishing year**
Southern red hake landings	731,124	332	20%	30%	-24%
Southern red hake state-permitted only vessel landings	3,388	2	0%	0%	0%
Southern red hake estimated discard	1,675,274	760	47%	70%	-31%
Southern red hake recreational landings (MRIP)	288,580	131	n/a	n/a	420%
Southern red hake catch*	2,409,786	1,093	**67%**	100%	-29%

* Total catch does not include recreational landings as the Annual Catch Limit does not include recreational landings.

Table 11. Fishing year 2016 whiting landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (23,161 mt)	Percent of Total Catch	Percent Change from prior fishing year
Northern silver hake commercial landings	6,802,115	3,085	13%	90%	39%
Northern silver hake state-permitted only vessel landings	25,321	11	0%	0%	
Northern silver hake estimated discard	710,678	322	1%	9%	5%
Northern silver hake recreational landings (MRIP)	109,228	50	0%	1%	176%
Northern silver hake catch*	7,538,114	3,419	**15%**	100%	34%
	Pounds	**Metric tons**	**Percent of ACL (29,261 mt)**	**Percent of Total Catch**	**Percent Change from prior fishing year**
Southern whiting landings	6,652,748	3,018	10%	79%	-18%
Southern whiting state-permitted only vessel landings	3,831	2	0%	0%	27%
Southern whiting estimated discard	1,816,659	824	3%	21%	137%
Southern whiting recreational landings (MRIP)	5	0	0%	n/a	
Southern whiting catch*	8,473,238	3,843	**13%**	100%	-4%

* Total catch does not include recreational landings as the Annual Catch Limit does not include recreational landings.

6.2 Trends in permit issuance, vessel participation, and dealer participation in the fishery

Any vessel issued a limited access Northeast multispecies permit categories A, C, E, and F or an open access Northeast multispecies permit category K can fish for and land small mesh multispecies. As such, the number of category K permits is not necessarily related to the number of participating vessels (Table 14).

Although the number of Category K permits peaked in 2005 and has declined to 794 in 2016, the number of trips, vessels, and dealers landing small-mesh multispecies has a different pattern in the northern and southern management areas. In the northern management area, landings declined from 1996 to 822 mt in 2008, but have been increasing since to 2,844 mt in 2016. The number of trips have recently been relatively stable between 866-1,358 during 2007-2016, while the number of dealers and vessels has remained stable (Table 14). Thus it appears that vessels are landing more small-mesh multispecies per trips as a result of increased targeting of small-mesh multispecies.

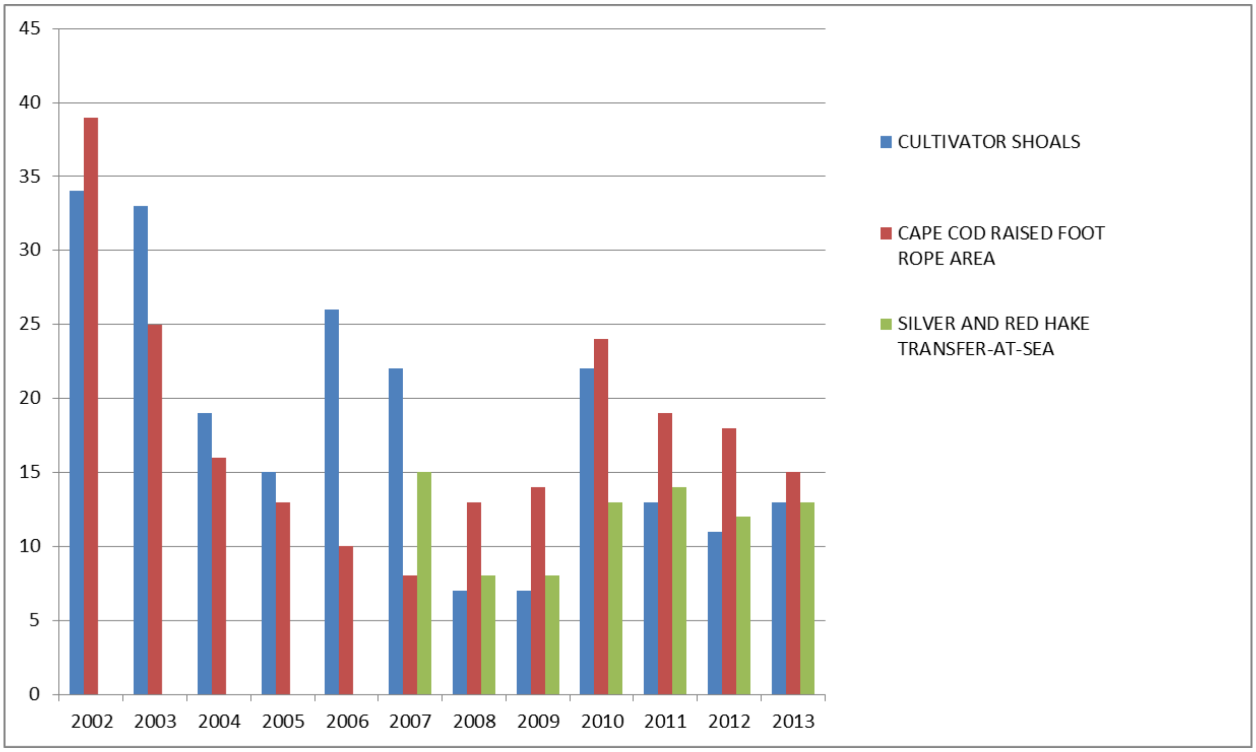
In the southern management area, landings have steadily declined through the 1996-2016 period, while the number of dealers and vessels have been relatively stable since 2004. The number of trips landing small-mesh multispecies have been relatively stable from 2002-2015, but dropped considerably in 2016 (Table 14).

Table 12. Landings with number of trips, dealers, and vessels landing small-mesh multispecies by management area, with Category K small-mesh multispecies open access permits and issued letter of authorizations.

	Manage										
	Northern				Southern				Cat K permits	Letter of Authorizations	
Fishing ye	Trips.	Dealers.	Vessels .	Landings, mt live wt	Trips.	Dealers.	Vessels.	Landings, mt live wt	Issued	Cultivator Shoals Area	Small Mesh Areas
1996	5,302	73	199	4,357	8,620	127	227	10,891	150		
1997	3,359	69	132	3,019	9,558	111	250	11,013	435		
1998	2,601	62	135	2,336	9,070	108	253	11,167	537		
1999	2,696	58	105	3,917	7,585	98	239	9,080	629		
2000	1,997	45	74	3,135	6,560	83	214	9,855	722		
2001	2,183	47	76	3,632	5,794	75	196	8,211	761		
2002	2,035	49	69	2,902	4,704	73	170	5,094	839		
2003	1,206	40	49	2,093	4,963	75	164	7,308	855	32	25
2004	977	40	47	1,121	3,979	71	142	7,021	913	19	28
2005	525	24	22	673	3,499	67	142	6,533	1,051	15	14
2006	644	32	40	1,006	4,058	71	167	4,801	1,022	26	10
2007	960	36	40	1,184	4,911	66	158	6,432	1,022	22	8
2008	915	22	33	822	4,722	63	154	6,221	998	7	13
2009	1,076	29	35	1,194	5,458	63	136	7,457	948	7	14
2010	1,358	33	49	1,781	4,648	63	136	6,218	904	22	6
2011	1,279	25	45	1,777	4,682	56	115	5,935	815	10	0
2012	1,227	31	43	1,643	4,623	54	114	5,169	806		
2013	957	25	33	1,380	5,568	61	125	5,200	777		
2014	866	20	22	2,235	5,322	55	130	4,670	774		
2015	1,032	20	26	1,943	4,584	50	125	3,890	781		
2016	1,239	20	27	2,844	2,986	44	110	2,131	794		
2017									747		

Participation in the small-mesh fishery in the Gulf of Maine/Georges Bank Regulated Mesh Area is only allowed in specific exemption programs, as described in the Background section. Some of these exemption programs require the vessel owner to obtain a Letter of Authorization (LOA) from the Regional Administrator in order to participate. The Cultivator Shoals Whiting Exemption Area and the Raised Footrope Trawl Exemption Area around Cape Cod require an LOA. In addition, vessels may transfer a portion of their catch to another vessel at sea, provided they have an LOA. The trends in LOA issuance are shown in Figure 6.

Figure 6. Issuance of letters of authorization for the small mesh fishery by fishing year



6.3 Trends in Revenue and Port Participation

Most of the small-mesh multispecies revenue derived from small-mesh multispecies trips fishing in the northern management area were landed in MA, where more than 95% of the value from these vessels were from small-mesh multispecies landings (i.e. small-mesh multispecies revenue divided by total trip value) (Table 13). Trips fishing in the northern management area during 2014-2016 landed their catch in ME to NY.

Most of the small-mesh multispecies revenue derived from small-mesh multispecies trips fishing in the southern management area were also landed in MA, but only about 2/3rds of the value from these vessels were from small-mesh multispecies landings (i.e. small-mesh multispecies revenue divided by total trip value) (Table 13). The remainder was presumably from landings of squid. Trips fishing in the southern management area during 2014-2016 landed their catch in MA to NJ. Small-mesh multispecies revenue in MA was closely followed by revenue in RI and CT, where an even greater share of landings by these vessels using small-mesh was also derived from other species. Over a longer period of time, there has been a notable shift in small-mesh multispecies landings from NY, CT, and RI to MA, particularly in New Bedford, MA.

For landings coming from the northern management area, Gloucester MA ($1.8 million) replaced New Bedford MA ($906 thousand) as the top port in 2016 (Table 14). For landings in the southern management area New Bedford accounted for $2.2 million in small-mesh multispecies revenue, followed by Point Judith, RI ($1.5 million) and Montauk, NY ($1.1 million).

Table 13. Small-mesh multispecies revenue and total trip value by vessels targeting small-mesh multispecies by management area and state of landing. Source VTR data.

MGMT_AREA	STATE	Values	2014	2015	2016
Northern	CT	Small-mesh revenue.	33,385	110,639	-
		Total trip value	44,075	119,012	
	MA	Small-mesh revenue.	3,025,380	2,803,322	2,952,177
		Total trip value	3,147,930	2,984,095	3,156,239
	ME	Small-mesh revenue.	21,721	6,595	-
		Total trip value	21,907	6,595	
	NH	Small-mesh revenue.	83,902	127,179	274,631
		Total trip value	109,611	165,706	317,246
	NY	Small-mesh revenue.	64,717	67,557	359,961
		Total trip value	66,776	76,032	365,611
	RI	Small-mesh revenue.	12,784	-	462,335
		Total trip value	13,196		498,262
Northern Small-mesh revenue.			3,241,888	3,115,292	4,049,105
Northern Total trip value			3,403,495	3,351,440	4,337,358
Southern	CT	Small-mesh revenue.	1,361,061	1,099,365	1,017,655
		Total trip value	3,059,234	2,784,938	3,076,691
	MA	Small-mesh revenue.	2,523,282	3,160,189	2,204,045
		Total trip value	3,469,299	4,925,761	4,245,747
	NJ	Small-mesh revenue.	429,394	147,609	53,858
		Total trip value	3,222,127	2,655,271	5,770,519
	NY	Small-mesh revenue.	1,760,715	1,303,300	1,183,641
		Total trip value	5,974,462	4,833,224	5,581,447
	RI	Small-mesh revenue.	1,112,346	782,721	1,466,462
		Total trip value	11,161,265	12,030,039	22,952,366
Southern Small-mesh revenue.			7,186,797	6,493,185	5,925,661
Southern Total trip value			26,886,387	27,229,233	41,626,769

Table 14. Small-mesh multispecies revenue and total trip value at top ports by vessels targeting small-mesh multispecies by management area and state of landing. Source VTR data

MGMT_AREA	STATE	PORT	Values	2014	2015	2016
Northern	MA	BOSTON	Small-mesh revenue.	-	160,966	105,673
			Total trip value		164,407	137,750
		GLOUCESTER	Small-mesh revenue.	876,159	1,373,986	1,853,183
			Total trip value	919,413	1,422,765	1,919,152
		NEW BEDFORD	Small-mesh revenue.	2,107,761	1,177,383	905,627
			Total trip value	2,183,645	1,299,047	998,749
		PROVINCETOWN	Small-mesh revenue.	36,555	90,987	86,991
			Total trip value	39,543	97,876	99,699
	NH	SEABROOK	Small-mesh revenue.	77,789	116,871	262,754
			Total trip value	100,932	145,787	301,702
	NY	NEW YORK CITY	Small-mesh revenue.	44,343	67,557	359,961
			Total trip value	46,244	76,032	365,611
	RI	POINT JUDITH	Small-mesh revenue.	12,784	-	462,335
			Total trip value	13,196		498,262
Northern Small-mesh revenue.				3,155,391	2,987,750	4,036,524
Northern Total trip value				3,302,973	3,205,914	4,320,924
Southern	CT	STONINGTON	Small-mesh revenue.	108,551	83,724	96,997
			Total trip value	621,357	611,562	743,911
	MA	BOSTON	Small-mesh revenue.	1,195	3,425	1,462
			Total trip value	39,542	117,513	248,218
		NEW BEDFORD	Small-mesh revenue.	2,522,087	3,154,499	2,202,514
			Total trip value	3,429,758	4,800,245	3,993,461
	NY	MONTAUK	Small-mesh revenue.	1,677,003	1,254,609	1,160,126
			Total trip value	5,121,125	4,462,021	5,107,993
	RI	POINT JUDITH	Small-mesh revenue.	1,112,346	782,387	1,466,198
			Total trip value	11,161,265	11,022,788	17,533,885
Southern Small-mesh revenue.				5,421,183	5,278,644	4,927,296
Southern Total trip value				20,373,045	21,014,129	27,627,469

6.4 Dependence on Small-Mesh Fishery

Because small-mesh multispecies are landed both as directed stocks as well as incidentally to several other fisheries, it can be useful to examine the level of dependence vessel owners have on this fishery. In general, for the overwhelming majority of vessels that land small-mesh species, it contributes only a fraction of their overall revenue. There are a handful of vessels that appear to depend heavily on small-mesh multispecies, but especially with historical data, the information as displayed should be interpreted with caution.

Vessel dependence

Considering trips landing any amount of small-mesh multispecies, (Table 13, upper panel), most (e.g. 231 vessels in 2016) of the vessels derive less than 10% of their total revenue from landings of small-mesh multispecies. Many of these vessels participate in other fisheries, particularly large mesh trawls and gillnets targeting groundfish, monkfish, and skates.

Restricting the analysis to trips landing more than 2000 lbs. of whiting (often considered as an incidental amount), a greater proportion of vessels derived most of their revenue from landings of small-mesh multispecies (Table 13, lower panel). During 2016, there were 55 vessels that derived more than 50% of annual revenue from landings of small-mesh multispecies (Table 14). This is equivalent to 20% of vessels that landed more than 2000 lbs. of whiting on at least one trip during 2016. This an increase of 4 vessels, but a decrease by 1% compared to 2015, and generally lower than the values for 2007-2014.

In the northern management area, silver hake landings by vessels deriving more than 50% of revenue from small-mesh multispecies increased from 3.9 million lbs. in 2015 to 6.0 million lbs. in 2016, the highest since 2001 (Table 15). Red hake landings also increased to 221 thousand lbs., the highest since 2006. In contrast, silver hake landings in the southern management area by similar vessels declined from 6.6 to 3.7 million lbs., respectively. The 2016 small-mesh multispecies landings by vessels with a high dependence on small-mesh multispecies is the lowest in the time series. Red hake landings in the southern management area declined slightly to 187 thousand lbs., the second lowest in the time series.

Table 15. Annual distribution of the dependence of small-mesh multispecies revenue, by categories of small-mesh multispecies revenue as a proportion of the revenue for all species.

Vessels landing more than one pound of whiting on any trip

Revenue Target%	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Target_LT10%	77	78	111	101	130	141	179	151	127	144	130	129	144	103	126	176	157	163	176	147	231
Target_10-20%	96	30	132	114	17	74	25	52	74	54	58	50	21	11	41	16	26	21	35	38	15
Target_20-30%	20	112	15	47	89	8	83	75	61	3	48	18	41	39	19	23	40	23	52	17	12
Target_30_40%	130	27	23	47	58	63	3	5	4	8	26	41	55	6	34	58	40	30	25	45	3
Target_40-50%	38	98	89	35	9	28	25	7	22	55	28	22	10	37	34	10	38	1	18	5	54
Target_50-60%	8	27	24	18	56	74	30	22	22	19	13	53	32	49	46	38	23	33	32	6	1
Target_60-70%	11	29	5	5	27	49	14	20	17	20	5	9	10	13	35	4	13	11	10	5	16
Target_70-80%	12	17	27	13	11	21	8	30	32	3	8	14	18	19	13	9	18	17	6	10	11
Target_80-90%	30	20	13	13	12	14	45	5	17	3	10	16	30	34	17	24	7	14	11	11	6
Target_GT90%	83	55	61	59	70	83	54	55	34	27	26	23	26	20	29	38	35	30	22	25	28

Vessels landing more than 2000 pounds of whiting on one or more trips in a year

Revenue Target%	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Target_LT10%	31	28	33	30	87	72	114	107	83	79	82	82	86	56	71	116	116	99	112	94	138
Target_10-20%	86	25	126	106	8	66	21	50	70	53	54	47	19	9	36	7	10	20	32	33	11
Target_20-30%	20	107	14	46	85	7	83	70	58	3	47	13	41	38	17	21	37	20	50	14	12
Target_30_40%	126	25	20	46	49	51	0	4	4	8	24	31	54	5	30	58	38	27	24	45	3
Target_40-50%	33	90	85	32	8	27	24	6	21	52	28	20	9	36	32	10	33	0	18	1	51
Target_50-60%	8	26	24	10	55	73	30	16	22	19	13	52	26	48	45	38	18	33	32	6	1
Target_60-70%	10	27	3	4	27	49	14	16	16	18	5	6	10	12	32	3	10	11	10	5	16
Target_70-80%	10	9	22	8	11	18	8	29	31	2	5	12	17	19	13	7	18	16	6	8	8
Target_80-90%	28	15	12	12	12	13	40	5	16	7	0	16	29	32	14	21	6	10	11	11	6
Target_GT90%	70	46	56	54	64	77	48	49	27	25	26	18	24	17	26	32	28	26	17	21	24

Table 16. Number and proportion of vessels deriving most of annual income from small-mesh multispecies landings, for vessels landing over 2000 lbs. of whiting on one or more trips during the year.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total > 50%	126	123	117	88	169	230	140	115	112	71	49	104	106	128	130	101	80	96	76	51	55
Percent	30%	31%	30%	25%	42%	51%	37%	33%	32%	27%	17%	35%	34%	47%	41%	32%	25%	37%	24%	21%	20%

Table 17. Annual landings by management areas for vessels deriving more than 50% of income from landings of small-mesh multispecies.

Northern

YEAR	Silver hake	Red hake	Herring, lbs.	Loligo squid
1996	4,500,168	715,941	239,678	13,631
1997	3,976,595	472,755	16,308	12,744
1998	4,074,365	357,560	8,245	4,206
1999	6,910,418	336,473	70,553	28,033
2000	6,213,094	468,653	520	27,052
2001	7,399,907	474,254	27,375	88,626
2002	5,149,239	651,124	65,325	22,716
2003	3,918,620	559,053	13,035	21,873
2004	1,888,024	188,689	94,860	18,810
2005	1,245,276	136,591	25,250	1,220
2006	1,710,454	228,480	38,200	61,930
2007	2,126,107	130,526	86,637	3,327
2008	1,331,589	102,503	30,430	19,045
2009	2,051,997	165,059	66,200	21,108
2010	3,320,144	155,971	25,235	13,512
2011	3,297,133	142,364	13,397	15,243
2012	3,052,576	147,220	24,880	87,518
2013	2,603,810	173,415	12,990	21,164
2014	4,824,552	116,045	24,860	28,504
2015	3,924,043	160,755	65,675	21,423
2016	5,960,856	221,485	136,440	42,808

Southern

YEAR	Silver hake	Red hake	Herring, lbs.	Loligo squid
1996	7,658,832	251,661	3,620	531,252
1997	5,563,119	238,789	1,739	1,038,432
1998	5,998,284	256,886	49,489	1,322,882
1999	4,240,568	163,557	11,380	380,260
2000	10,246,307	1,191,459	1,994	1,769,701
2001	11,541,943	1,566,402	3,857	3,492,399
2002	4,836,040	353,367	7,195	1,624,538
2003	7,589,196	450,839	48,996	2,247,666
2004	7,902,371	585,620	3,939	1,543,959
2005	7,406,317	306,355	1,606	2,312,469
2006	3,812,190	347,327	2,475	828,461
2007	6,080,850	595,499	4,716	962,882
2008	7,266,734	655,546	13,904	1,067,207
2009	9,878,357	950,965	19,822	1,315,784
2010	8,543,119	637,899	10,267	1,369,321
2011	7,824,530	525,342	8,605	1,047,800
2012	6,094,501	368,148	335	846,395
2013	7,251,855	394,465	3,256	1,130,151
2014	6,362,106	295,467	8,625	1,011,372
2015	6,596,364	190,906	87	1,220,423
2016	3,679,609	187,308	115	914,081

Dealer/port dependence

The number of dealers landing small-mesh multispecies has remained relatively steady over the time series, ranging from 957 in 2013 to 686 in 2005 (Table 16). Generally, more than 95% of them derive less than 10% of annual income from the landings of small-mesh multispecies. Less than 10 dealers derive the majority of income from small-mesh multispecies landings, seven dealers in 2016. Some of the annual variation in dealer dependence is a function of landed value of other species in as much it is due to revenue from small-mesh multispecies.

In the northern management area, there were 276 dealers that derived income from vessels targeting small-mesh multispecies, 141 dealers in MA totaling $8.8 million (Table 16). Counting landings of other species by vessels that targeted small-mesh multispecies (this includes trips using large mesh trawls and other gears) brought the total at MA dealers to $14.1 million. In the southern management area, there were 1,220 dealers deriving income from vessels targeting small-mesh multispecies, 565 of them in NY totaling $4.3 million in small-mesh multispecies revenue. Counting landings of other species by vessels that targeted small-mesh multispecies (this includes trips using large mesh trawls and other gears) brought the total at NY dealers to $28.8 million. Small-mesh multispecies vessels landing trips in RI were more diversified with revenue from small-mesh multispecies totaling $3.5 million, but were $56.7 million when landings of other trips by these vessels were included (many of them landing squid?).

Table 18. Number of dealers categorized by the proportion of annual revenue from small-mesh multispecies.

	No. of DEALERS with Dependency on Hakes Value relative to Total Fish Value					
	<10%	10-25%	25-50%	50-75%	>75%	Total No. of Dealers
1996	591	59	33	27	0	710
1997	523	140	27	1	0	691
1998	567	135	24	0	0	726
1999	655	130	47	1	0	833
2000	705	111	1	0	0	817
2001	631	187	2	0	1	821
2002	758	92	2	1	3	856
2003	727	103	3	0	1	834
2004	677	40	3	0	5	725
2005	640	42	1	0	3	686
2006	742	9	1	2	0	754
2007	716	0	12	0	1	729
2008	653	56	4	5	3	721
2009	701	40	2	0	2	745
2010	782	50	3	3	1	839
2011	839	11	9	2	1	862
2012	829	73	1	1	1	905
2013	882	51	22	2	0	957
2014	752	44	0	2	0	798
2015	842	21	1	2	0	866
2016	726	19	1	0	7	753

Table 19. Number of dealers with landings from vessels deriving more than 50% of income from landings of small-mesh multispecies.

STATE	Northern Dealers.	Small-mesh revenue.	Total trip value	Southern Dealers.	Small-mesh revenue.	Total trip value
CT	15	144,024	$163,087	174	3,490,798	$9,580,821
MA	141	8,837,177	$14,176,754	89	7,892,763	$14,763,856
ME	55	30,800	$1,294,667		-	
NH	46	568,890	$952,822	2	27	$929
NJ		-		159	719,089	$15,088,057
NY	15	492,256	$510,665	565	4,347,963	$28,766,171
RI	4	475,121	$511,467	231	3,510,277	$56,688,103
Total	**276**	**10,548,268**	**$17,609,461**	**1,220**	**19,960,916**	**$124,887,938**

6.5 *Trends in Landings*

Since 2000, nearly all landings of small-mesh multispecies originated from vessels using small- and large-mesh trawls in both management areas (Table 17). Landings by other gears were a small fraction of the total.

In 2016, most of the trawl-caught small-mesh multispecies landings came from vessels using 2.5 to 3-inch mesh trawls, 92% for whiting and 65% for red hake (Table 18). Nearly all of the remainder came from vessels using 2.1 to 2.5-inch mesh trawls in the northern management area (which includes the Cultivator Shoals Area) in the Atlantic herring and squid fisheries.

Table 20. Landings of small-mesh multispecies from 1999-2016 by gear. Source VTR data.

		GEAR_TYPE Values									
		Gill net		Mid-water trawl		Trawl		Other		Total Whiting, lb	Total Red hake, lb
YEAR	MGMT_AREA	hiting, lbs. liv	Red hake, lbs. live	hiting, lbs. liv	Red hake, lbs. live	hiting, lbs. liv	Red hake, lbs. live	hiting, lbs. liv	Red hake, lbs. live		
2000	Northern	13,210	780	-		6,378,786	538,391	114,194	11,995	6,506,190	551,166
	Southern	-		-		12,303,356	1,351,912	-	4,897	12,303,356	1,356,809
2000 Total		**13,210**	**780**	**-**		**18,682,142**	**1,890,303**	**114,194**	**16,892**	**18,809,546**	**1,907,975**
2001	Northern	-		-		7,852,592	568,058	155,984	23,325	8,008,576	591,383
	Southern	6,500	-	-		12,953,202	1,635,222	7,002	12,993	12,966,704	1,648,215
2001 Total		**6,500**	**-**	**-**		**20,805,794**	**2,203,280**	**162,986**	**36,318**	**20,975,280**	**2,239,598**
2002	Northern	-		400	-	5,653,543	769,219	16,906	1,410	5,670,849	770,629
	Southern	-		-		5,799,782	465,436	1,800	125	5,801,582	465,561
2002 Total		**-**		**400**	**-**	**11,453,325**	**1,234,655**	**18,706**	**1,535**	**11,472,431**	**1,236,190**
2003	Northern	-		-		4,031,473	617,383	81,002	7,830	4,112,475	625,213
	Southern	-		-		9,027,422	770,212	5,000	-	9,032,422	770,212
2003 Total		**-**		**-**		**13,058,895**	**1,387,595**	**86,002**	**7,830**	**13,144,897**	**1,395,425**
2004	Northern	-		-		2,216,992	242,944	24,550	4,450	2,241,542	247,394
	Southern	-	63	-		8,570,137	732,885	20,750	1,425	8,590,887	734,373
2004 Total		**-**	**63**	**-**		**10,787,129**	**975,829**	**45,300**	**5,875**	**10,832,429**	**981,767**
2005	Northern	-		-		1,278,001	199,566	-		1,278,001	199,566
	Southern	-		-		9,146,063	521,531	991	-	9,147,054	521,531
2005 Total		**-**		**-**		**10,424,064**	**721,097**	**991**	**-**	**10,425,055**	**721,097**
2006	Northern	-		-		1,919,248	286,440	-		1,919,248	286,440
	Southern	-		-		3,830,260	347,927	-	96	3,830,260	348,023
2006 Total		**-**		**-**		**5,749,508**	**634,367**	**-**	**96**	**5,749,508**	**634,463**
2007	Northern	-		-		2,316,267	208,866	-		2,316,267	208,866
	Southern	-		-		6,494,750	606,579	-	26	6,494,750	606,605
2007 Total		**-**		**-**		**8,811,017**	**815,445**	**-**	**26**	**8,811,017**	**815,471**
2008	Northern	-		-		1,598,662	224,153	75	60	1,598,737	224,213
	Southern	7,740	2,160	-		7,656,019	660,716	-	1,100	7,663,759	663,976
2008 Total		**7,740**	**2,160**	**-**		**9,254,681**	**884,869**	**75**	**1,160**	**9,262,496**	**888,189**
2009	Northern	-		820	-	2,303,031	279,144	-		2,303,851	279,144
	Southern	-		-		10,210,238	954,565	60,000	1,978	10,270,238	956,543
2009 Total		**-**		**820**	**-**	**12,513,269**	**1,233,709**	**60,000**	**1,978**	**12,574,089**	**1,235,687**
2010	Northern	815	38	7,725	-	3,632,261	223,923	-		3,640,801	223,961
	Southern	-		-		8,785,972	639,916	-	115	8,785,972	640,031
2010 Total		**815**	**38**	**7,725**	**-**	**12,418,233**	**863,839**	**-**	**115**	**12,426,773**	**863,992**
2011	Northern	30	-	-		3,615,812	246,989	550	570	3,616,392	247,559
	Southern	-		-		7,856,404	525,465	3,000	-	7,859,404	525,465
2011 Total		**30**	**-**	**-**		**11,472,216**	**772,454**	**3,550**	**570**	**11,475,796**	**773,024**
2012	Northern	-		-		3,242,749	187,148	-		3,242,749	187,148
	Southern	-		-		6,133,189	391,394	-	297	6,133,189	391,691
2012 Total		**-**		**-**		**9,375,938**	**578,542**	**-**	**297**	**9,375,938**	**578,839**
2013	Northern	-		-		2,696,334	217,891	3,046	540	2,699,380	218,431
	Southern	-		-		7,257,862	395,325	-	686	7,257,862	396,011
2013 Total		**-**		**-**		**9,954,196**	**613,216**	**3,046**	**1,226**	**9,957,242**	**614,442**
2014	Northern	-		6,744	-	4,863,007	118,940	1,000	-	4,870,751	118,940
	Southern	-		-		6,365,856	296,927	-	266	6,365,856	297,193
2014 Total		**-**		**6,744**	**-**	**11,228,863**	**415,867**	**1,000**	**266**	**11,236,607**	**416,133**
2015	Northern	-		-		4,013,805	162,975	24	-	4,013,829	162,975
	Southern	-		-		6,618,215	203,636	-	188	6,618,215	203,824
2015 Total		**-**		**-**		**10,632,020**	**366,611**	**24**	**188**	**10,632,044**	**366,799**
2016	Northern	250	-	-		6,052,391	317,365	23,625	4,275	6,076,266	321,640
	Southern	-		-		3,682,479	187,808	-	47	3,682,479	187,855
2016 Total		**250**	**-**	**-**		**9,734,870**	**505,173**	**23,625**	**4,322**	**9,758,745**	**509,495**

Table 21. Trawl landings of small-mesh multispecies from 1999-2016 by mesh size. Source VTR data.

	Mesh size	Values									
		<= 2.0		2.1-2.5		<3.0		3.1-5.5		>= 5.5	
YEAR	MGMT_AREA	Whiting, lbs. live	Red hake, lbs. live	Whiting, lbs. live	Red hake, lbs. live	Whiting, lbs. live	Red hake, lbs. live	Whiting, lbs. live	Red hake, lbs. live	Whiting, lbs. live	Red hake, lbs. live
1999 Total		**1,430,632**	**207,353**	**4,839,012**	**241,549**	**6,511,767**	**266,083**	**1,415,224**	**75,740**	**959,721**	**50,393**
2000	Northern	111,857	20,964	1,412,787	283,049	4,826,142	233,658	28,000	720	-	
	Southern	1,342,243	58,928	755,361	123,534	9,560,972	1,068,025	585,600	93,085	59,180	8,340
2000 Total		**1,454,100**	**79,892**	**2,168,148**	**406,583**	**14,387,114**	**1,301,683**	**613,600**	**93,805**	**59,180**	**8,340**
2001	Northern	65,688	28,540	906,146	160,204	6,665,881	358,905	181,520	17,319	33,357	3,090
	Southern	150	150	479,976	185,019	11,620,337	1,381,383	852,739	68,670	-	
2001 Total		**65,838**	**28,690**	**1,386,122**	**345,223**	**18,286,218**	**1,740,288**	**1,034,259**	**85,989**	**33,357**	**3,090**
2002	Northern	106,678	30,595	784,825	156,071	4,642,920	577,518	118,870	3,660	250	1,375
	Southern	55,395	8,123	507,682	80,647	4,402,758	272,720	829,723	103,946	4,224	-
2002 Total		**162,073**	**38,718**	**1,292,507**	**236,718**	**9,045,678**	**850,238**	**948,593**	**107,606**	**4,474**	**1,375**
2003	Northern	2,400	1,000	419,896	113,595	3,474,497	494,703	104,180	5,160	30,500	2,925
	Southern	-		49,449	9,826	7,602,116	443,762	1,300,857	307,124	75,000	9,500
2003 Total		**2,400**	**1,000**	**469,345**	**123,421**	**11,076,613**	**938,465**	**1,405,037**	**312,284**	**105,500**	**12,425**
2004	Northern	21,405	1,650	405,444	96,468	1,639,913	138,476	150,230	6,350	-	
	Southern	3,275	540	41,538	3,490	7,927,899	580,755	597,425	148,100	-	
2004 Total		**24,680**	**2,190**	**446,982**	**99,958**	**9,567,812**	**719,231**	**747,655**	**154,450**	**-**	
2005	Northern	-		152,077	86,463	1,125,924	113,103	-		-	
	Southern	-		86,727	7,569	7,667,060	300,136	1,366,276	213,706	26,000	120
2005 Total		**-**		**238,804**	**94,032**	**8,792,984**	**413,239**	**1,366,276**	**213,706**	**26,000**	**120**
2006	Northern	32,500	7,790	146,034	66,910	1,710,714	209,740	30,000	2,000	-	
	Southern	1,570	600	5,579	6,425	3,823,111	340,902	-		-	
2006 Total		**34,070**	**8,390**	**151,613**	**73,335**	**5,533,825**	**550,642**	**30,000**	**2,000**	**-**	
2007	Northern	126,755	9,600	261,087	71,486	1,880,285	126,180	48,140	350	-	1,250
	Southern	2,210	60	489,875	61,297	5,762,365	535,022	240,300	10,200	-	
2007 Total		**128,965**	**9,660**	**750,962**	**132,783**	**7,642,650**	**661,202**	**288,440**	**10,550**	**-**	**1,250**
2008	Northern	225,023	27,230	419,831	116,856	937,158	70,567	15,200	9,100	1,450	400
	Southern	3,610	310	378,568	74,512	7,029,681	580,374	244,160	5,520	-	
2008 Total		**228,633**	**27,540**	**798,399**	**191,368**	**7,966,839**	**650,941**	**259,360**	**14,620**	**1,450**	**400**
2009	Northern	138,041	8,071	461,661	111,479	1,703,329	159,594	-		-	
	Southern	44,286	700	483,695	72,900	9,555,037	877,105	127,220	3,860	-	
2009 Total		**182,327**	**8,771**	**945,356**	**184,379**	**11,258,366**	**1,036,699**	**127,220**	**3,860**	**-**	
2010	Northern	50,860	12,367	632,289	71,935	2,829,442	119,926	119,670	19,695	-	
	Southern	1,513	317	2,590	895	8,631,219	637,004	150,650	1,700	-	
2010 Total		**52,373**	**12,684**	**634,879**	**72,830**	**11,460,661**	**756,930**	**270,320**	**21,395**	**-**	
2011	Northern	167,434	7,245	535,288	99,629	2,813,730	121,785	98,800	18,230	560	100
	Southern	10,850	-	337,153	34,518	7,507,846	490,947	550	-	5	-
2011 Total		**178,284**	**7,245**	**872,441**	**134,147**	**10,321,576**	**612,732**	**99,350**	**18,230**	**565**	**100**
2012	Northern	164,696	11,170	638,797	71,239	2,438,489	104,739	-		767	-
	Southern	30,000	3,500	155,383	86,120	5,947,806	301,774	-		-	
2012 Total		**194,696**	**14,670**	**794,180**	**157,359**	**8,386,295**	**406,513**	**-**		**767**	**-**
2013	Northern	72,575	12,848	229,735	71,969	2,391,453	132,934	2,130	140	441	-
	Southern	-		170,030	43,478	7,087,817	351,847	-		15	-
2013 Total		**72,575**	**12,848**	**399,765**	**115,447**	**9,479,270**	**484,781**	**2,130**	**140**	**456**	**-**
2014	Northern	28,150	1,065	385,927	20,315	4,448,930	97,560	-		-	
	Southern	3,750	810	131,325	29,820	6,230,781	266,297	-		-	
2014 Total		**31,900**	**1,875**	**517,252**	**50,135**	**10,679,711**	**363,857**	**-**		**-**	
2015	Northern	85,078	1,450	366,398	36,585	3,561,705	124,940	544	-	80	-
	Southern	10	-	-		6,618,055	203,536	50	-	100	100
2015 Total		**85,088**	**1,450**	**366,398**	**36,585**	**10,179,760**	**328,476**	**594**	**-**	**180**	**100**
2016	Northern	26,130	9,100	781,821	168,880	5,242,340	139,385	2,100	-	-	
	Southern	-		-		3,679,609	187,308	-		2,870	500
2016 Total		**26,130**	**9,100**	**781,821**	**168,880**	**8,921,949**	**326,693**	**2,100**	**-**	**2,870**	**500**

6.6 *Bycatch in the small-mesh multispecies fishery*

Bycatch in the small-mesh multispecies fishery was estimated by applying the mean D/Kall ratios to landings off all species on trips using small-mesh trawls and landing 2000 lbs. of whiting or 400 lbs. of red hake, stratified by year, quarter, and management area. All observed tows on NEFOP and ASM were used to calculate the discard ratios (Table 23 and Table 24).

In the northern area (Table 22, left panel), haddock, red hake, winter skate, silver hake, and Atlantic herring were the top five species over 2014-2016. Haddock discards have been high as a result of an historically strong 2013 year class. It was also the top discard species in an experimental small-mesh trawl fishery conducted in June 2016 and observed by MA Division of Marine Fisehries. Red hake discards increased in response to a strong 2014 year class, which is now contributing to the increase in specifications for 2018-2020. Winter skate and silver hake discards increased during 2014-2016 for unknown reasons, but it is consistent with the higher silver hake landings (Tab???).

In the southern area, the top discards were comprised of spiny dogfish, red hake, silver hake, butterfish, and little skate (Table 22, right panel) during 2014-2016. Over the three years, haddock ranked ninth, but peaked in 2015, also in response to a strong 2013 year class. Larger haddock may have separated from the traditional whiting fishing grounds in 2016.

Table 22. Total discard estimates for vessels using small mesh trawls on trips landing more than 2000 lbs. of whiting or 400 lbs. of red hake. Source: D/Kall ratios on NEFOP and ASM small-mesh multispecies trips applied to landings of all species by year, quarter, and management area.

Northern

Total discard estimate. Species	2014	2015	2016
Haddock	1,356,364	725,582	2,628,644
Red hake	302,781	1,239,240	1,066,607
Winter skate	24,804	476,665	1,946,063
Spiny dogfish	275,011	783,754	743,267
Silver hake	342,391	76,388	1,073,490
Atlantic herring	256,309	1,002,654	19,522
Little skate	36,783	199,218	538,688
Barndoor skate	9,606	54,244	47,998
Witch flounder	6,721	43,474	42,835
White hake	4,335	37,785	33,564
American plaice	18,381	15,138	30,978
Summer flounder	43,680	4,804	1,903
Yellowtail flounder	11,131	19,074	13,283
Winter flounder	22,513	10,979	3,040
Butterfish	9,318	10,068	6,362
Monkfish	3,374	8,225	9,956
Windowpane flounder	7,312	5,495	7,722
Cod	3,617	1,517	2,313
Thorny skate	2,662	97	1,128
Ocean pout	191	1,814	982
Smooth skate	71	0	0
Total	**2,737,355**	**4,716,215**	**8,218,342**

Southern

Total discard estimate. Species	2014	2015	2016
Spiny dogfish	4,204,045	6,296,685	3,852,193
Red hake	2,862,465	5,531,730	5,888,135
Silver hake	2,564,149	778,213	3,486,793
Butterfish	2,659,829	1,744,847	1,167,749
Little skate	1,606,140	1,594,583	1,420,909
Summer flounder	487,665	1,019,419	830,884
Barndoor skate	888,726	448,181	637,342
Winter skate	460,083	416,631	1,007,638
Haddock	486,986	1,017,544	302,899
Monkfish	66,936	287,289	818,202
Witch flounder	78,020	205,271	77,022
Ocean pout	201,342	38,910	112,770
Atlantic herring	56,165	196,072	0
Winter flounder	77,813	17,357	106,531
Yellowtail flounder	153,206	8,637	11,806
Windowpane flounder	68,655	24,365	16,610
Cod	1,335	419	18,305
White hake	0	13,303	6,012
American plaice	56	326	162
Thorny skate	0	0	0
Smooth skate	0	0	0
Total	**16,923,616**	**19,639,780**	**19,761,962**

Table 23. D/Kall statistics from NEFOP and ASM observed tows on small-mesh multispecies trips in the northern management area.

		QUARTER	Statistic				
		1	1	3	3	4	4
YEAR	Values	Arithmetic Mean	Coefficient of Variation	Arithmetic Mean	Coefficient of Variation	Arithmetic Mean	Coefficient of Variation
2014	American plaice	0.002	0.654	0.024	4.222	0.002	2.863
2014	Atlantic herring	-		0.020	11.826	0.166	4.825
2014	Barndoor skate	0.001	2.646	0.002	6.931	0.003	1.986
2014	Butterfish	-		0.004	11.877	0.000	3.338
2014	Cod	-		0.001	6.804	0.001	3.127
2014	Haddock	0.002	0.654	0.402	3.501	0.095	0.827
2014	Little skate	-		0.008	7.210	0.007	2.724
2014	Monkfish	0.006	0.847	0.001	8.283	0.001	3.519
2014	Ocean pout	-		0.000	12.481	-	
2014	Red hake	0.002	2.236	0.286	4.573	0.017	1.843
2014	Silver hake	0.068	2.440	0.091	4.323	0.021	1.432
2014	Smooth skate	0.000	2.646	-		0.000	8.307
2014	Spiny dogfish	0.092	0.707	0.056	4.310	0.115	2.293
2014	Summer flounder	-		0.013	5.974	0.000	3.509
2014	Thorny skate	-		0.000	3.000	0.002	4.028
2014	White hake	0.004	1.083	0.001	4.532	0.002	3.503
2014	Windowpane flounder	-		0.001	9.428	0.003	2.718
2014	Winter flounder	-		0.006	6.350	0.001	2.996
2014	Winter skate	-		0.002	5.397	0.014	2.249
2014	Witch flounder	0.000	1.708	0.014	5.326	0.002	3.598
2014	Yellowtail flounder	-		0.007	5.689	0.005	1.712
2015	American plaice			0.010	5.708	0.012	1.406
2015	Atlantic herring			0.120	13.427	1.280	1.768
2015	Barndoor skate			0.023	9.692	0.014	2.236
2015	Butterfish			0.005	13.347	-	
2015	Cod			0.002	12.102	-	
2015	Haddock			0.712	6.566	0.333	1.758
2015	Little skate			0.174	11.003	0.007	1.491
2015	Monkfish			0.010	10.589	-	
2015	Ocean pout			0.004	11.147	-	
2015	Red hake			0.271	5.643	1.383	1.783
2015	Silver hake			0.020	9.684	0.064	1.953
2015	Smooth skate			-		-	
2015	Spiny dogfish			1.250	7.739	0.028	3.882
2015	Summer flounder			0.001	11.172	0.008	2.236
2015	Thorny skate			0.000	6.856	-	
2015	White hake			-		0.059	1.571
2015	Windowpane flounder			0.011	10.076	-	
2015	Winter flounder			0.010	10.189	-	
2015	Winter skate			0.190	6.039	0.010	1.482
2015	Witch flounder			0.011	6.328	0.056	1.251
2015	Yellowtail flounder			0.022	5.966	0.010	0.682
2016	American plaice			0.042	5.782	0.006	1.423
2016	Atlantic herring			0.007	6.668	0.018	1.895
2016	Barndoor skate			0.016	7.715	0.003	3.742
2016	Butterfish			0.004	14.171	-	
2016	Cod			0.002	11.579	-	
2016	Haddock			1.392	10.337	0.242	3.383
2016	Little skate			0.125	8.731	0.157	5.183
2016	Monkfish			0.006	9.111	0.006	4.800
2016	Ocean pout			0.000	16.149	0.001	2.098
2016	Red hake			0.475	9.247	0.078	3.585
2016	Silver hake			0.227	8.921	0.302	2.719
2016	Smooth skate			-		-	
2016	Spiny dogfish			0.047	5.407	0.748	3.536
2016	Summer flounder			0.001	4.413	-	
2016	Thorny skate			0.000	11.455	0.000	3.742
2016	White hake			0.009	5.527	0.003	2.604
2016	Windowpane flounder			0.002	3.767	-	
2016	Winter flounder			0.001	8.310	0.001	3.742
2016	Winter skate			0.531	10.768	0.172	4.493
2016	Witch flounder			0.015	5.717	0.048	3.400
2016	Yellowtail flounder			0.018	6.773	0.001	3.742

Table 24. D/Kall statistics from NEFOP and ASM observed tows on small-mesh multispecies trips in the southern management area.

	QUARTER / Statistic	1	1	2	2	3	3	4	4
YEAR	Values	Arithmetic Mean	Coefficient of Variation	Arithmetic Mean	Coefficient of Variation	Arithmetic Mean	Coefficient of Variation	Arithmetic Mean	Coefficient of Variation
2014	American plaice	-		-		0.000	6.083	-	
2014	Atlantic herring	0.001	8.367	0.038	5.129	-		0.001	2.828
2014	Barndoor skate	0.048	6.371	0.101	9.924	0.014	5.214	0.082	6.592
2014	Butterfish	0.152	2.198	0.157	5.630	0.362	4.898	0.480	3.966
2014	Cod	-		0.001	3.051	-		-	
2014	Haddock	0.003	5.993	0.039	13.351	0.096	2.864	0.042	1.981
2014	Little skate	0.001	4.034	0.209	7.246	0.626	5.054	0.277	3.572
2014	Monkfish	0.004	2.565	0.014	7.747	0.000	6.083	0.012	5.689
2014	Ocean pout	-		0.156	3.541	-		-	
2014	Red hake	0.093	2.393	0.731	8.698	0.795	2.855	0.140	5.277
2014	Silver hake	0.027	5.512	0.366	4.625	0.887	3.204	0.105	6.015
2014	Smooth skate	-		-		-		-	
2014	Spiny dogfish	0.307	3.301	0.588	7.337	0.063	4.560	0.170	3.716
2014	Summer flounder	0.034	2.360	0.056	8.782	0.002	6.083	0.030	4.776
2014	Thorny skate	-		-		-		-	
2014	White hake	-		-		-		-	
2014	Windowpane flounder	0.007	8.190	0.008	4.790	0.012	3.113	0.000	2.236
2014	Winter flounder	-		0.021	4.884	0.032	4.969	0.010	2.178
2014	Winter skate	0.032	5.791	0.001	6.403	0.304	3.584	0.001	7.032
2014	Witch flounder	0.009	4.378	0.016	7.622	0.000	8.911	0.001	7.032
2014	Yellowtail flounder	0.010	8.205	0.000	2.823	0.122	6.197	0.018	3.399
2015	American plaice	-		-		0.000	6.708	0.000	9.381
2015	Atlantic herring	0.003	7.141	0.199	7.966	0.003	4.708	0.008	8.626
2015	Barndoor skate	0.046	4.150	0.076	5.832	0.020	4.820	0.041	6.241
2015	Butterfish	0.238	5.590	0.040	5.481	0.106	1.609	0.106	9.339
2015	Cod	-		0.000	9.592	-		0.000	9.381
2015	Haddock	0.001	5.256	0.127	3.180	0.047	1.936	0.129	8.966
2015	Little skate	0.039	5.925	0.773	6.996	0.193	3.234	0.093	6.004
2015	Monkfish	0.044	3.822	0.051	8.262	0.003	2.929	0.020	4.998
2015	Ocean pout	0.002	6.469	0.008	8.163	0.000	6.059	0.000	12.059
2015	Red hake	0.520	4.179	0.358	7.193	0.229	3.329	0.651	2.779
2015	Silver hake	0.021	2.423	0.024	3.222	0.140	3.735	0.209	6.161
2015	Smooth skate	-		-		-		-	
2015	Spiny dogfish	0.700	3.360	1.306	7.167	0.006	3.625	0.535	8.910
2015	Summer flounder	0.296	4.900	0.073	7.005	0.020	2.652	-	
2015	Thorny skate	-		-		-		-	
2015	White hake	0.003	4.583	-		0.000	3.847	0.000	7.611
2015	Windowpane flounder	-		0.001	7.781	0.009	4.482	-	
2015	Winter flounder	-		0.001	6.810	0.006	4.404	-	
2015	Winter skate	0.068	7.792	0.107	6.934	0.010	5.569	-	
2015	Witch flounder	0.040	3.481	0.016	9.236	0.001	4.559	-	
2015	Yellowtail flounder	-		-		0.003	3.564	-	
2016	American plaice	0.000	7.141	-		-		-	
2016	Atlantic herring	-		-		-		-	
2016	Barndoor skate	0.240	5.200	0.017	4.330	0.004	4.800	0.001	4.506
2016	Butterfish	0.436	6.189	0.091	3.504	0.077	5.074	0.046	2.583
2016	Cod	0.004	5.541	-		-		-	
2016	Haddock	0.066	2.053	0.005	7.728	0.002	3.437	0.001	3.139
2016	Little skate	0.046	5.643	0.028	3.362	0.141	1.263	0.226	3.702
2016	Monkfish	0.151	5.776	0.019	6.617	0.008	1.741	0.062	2.953
2016	Ocean pout	0.006	2.260	0.017	2.395	0.000	4.963	-	
2016	Red hake	0.844	4.226	0.508	5.705	0.025	1.328	0.098	2.367
2016	Silver hake	0.021	3.547	0.506	7.249	0.054	2.630	0.234	1.320
2016	Smooth skate	-		-		-		-	
2016	Spiny dogfish	2.132	7.761	0.040	5.247	0.029	3.119	0.014	3.667
2016	Summer flounder	0.715	5.349	0.002	3.124	0.007	2.042	0.029	2.810
2016	Thorny skate	-		-		-		-	
2016	White hake	0.000	7.141	-		0.002	5.616	-	
2016	Windowpane flounder	0.001	3.162	0.001	4.003	0.005	1.938	-	
2016	Winter flounder	-		0.008	3.148	0.022	2.518	0.003	6.691
2016	Winter skate	0.234	2.154	0.003	5.353	0.010	3.563	-	
2016	Witch flounder	0.017	7.669	0.006	2.268	0.000	5.320	0.000	4.840
2016	Yellowtail flounder	-		-		0.004	2.128	0.001	5.096

7.0 Fishery Cost Information

Due to limited time and resources, this information on fishing costs was not updated for this SAFE Report, but is still relevant to current circumstances and is repeated here.

7.1 Background

Commercial fishing vessels typically incur three major types of costs: fixed costs, variable costs and crew payments. Fixed costs, or non-trip costs, include all those costs that fishing vessel owners incur regardless how many fishing trips are taken. Some non-trip costs incurred by the vessel owner are associated with the each of the vessels owned, such mooring and dockage fees and vessel insurance premiums. Other non-trip costs are associated with the vessel owner's overall fishing business, and can be thought of as overhead costs, such as office expenses, professional fees, and business vehicle use costs. Trip costs, or operating costs, are those costs typically incurred during a fishing trip. Finally, the vessel owner makes payments to crew that he or she employs, which may include a hired captain for trips where the vessel owner is not the vessel operator. The term “annual costs” is sometimes used to refer to the combination of fixed costs and crew payments.

7.2 Fixed Cost and Crew Payment Information for Small Mesh Multispecies Vessels

At this time, an annual time series for fixed costs is not available. The Social Sciences Branch (SSB) of NEFSC has been working to collect data on annual costs, which consist of fixed costs and crew payments. This cost data is needed to meet the legislative requirements of the Magnuson-Stevens Fishery Conservation and Management Act, the National Environmental Policy Act, Executive Order 12866 and the Regulatory Flexibility Act, and allows the SSB to provide estimates of the economic and social impacts of proposed and final fishery management actions.

In 2012, SSB/NEFSC launched a modified cost data collection program after a careful review of an earlier cost data collection efforts.[4] These efforts included a cost data collection, designed to collect fixed costs and crew payments, that sampled each commercial fishing vessel in the Northeast region, in each year, over the three years from 2006-2008. This initial effort to collect fixed cost and crew payment data yielded inadequate response rates, beginning with a high of 22% in 2006, but falling to 8% by 2008.

The SSB’s most recent cost data collection effort included increased outreach, as well as a modified survey instrument and a stratified sampling approach to reduce respondent burden and fatigue. In 2012, a re-designed cost survey was mailed to commercial vessel owners in the Northeast region for cost incurred in 2011. In 2013, the cost survey instrument was modified very slightly based on challenges that arose in the data collected from the previous year's survey. The survey instrument used for costs incurred in 2012 contained seven sections: Section A focused on questions about vessel characteristics; Section B collected repair and maintenance, as well as upgrade and improvement costs; Section C contained questions about vessel related costs; Section D focused on questions about operating (trip) costs; Section E collected information about crew payments; Section F focused on costs associated with the vessel owner’s overall fishing business, which may include more than one vessel; and Section G inquired about other costs not covered in the previous sections of the survey instrument.

[4] See Das, An overview of the annual cost survey protocol and results in the northeastern region (2007-2009). NOAA Technical Memorandum NMFS-NE-226, 2014.

The modified survey effort aimed to sample approximately half of the population of commercial fishing vessels in the Northeast region each year. Vessels for the survey were selected using stratified sampling from the commercial fishing vessel population in the Northeast based on primary gear group (dredge, gillnet, handgear, pot/trap, purse seine, and trawl) and vessel length (larger than the average vessel in the primary gear group and smaller than the average vessel in the primary gear group). If a vessel owner owned more than one vessel, he or she was sent a survey for one vessel only. The number of vessel owners that received the survey for costs incurred in 2011 was 1,457; for costs incurred in 2012, 1,778 vessel owners received a survey. Vessel owners received the cost survey by mail, and could return it either in hard copy by mail, or complete it online using a unique password.

Overall response rates for the annual cost survey were 28.9% (372 surveys) for costs incurred in 2011 and 20.6% (367 surveys) for costs incurred in 2012. Statistical testing was performed to explore non-response bias and other potential biases. The survey data was then weighted to address these issues. The SSB is concerned with the data collection burden placed on commercial fishermen by this survey and other data collection efforts both within the National Marine Fisheries Service (NMFS) and externally. Therefore, at this time the SSB intends to repeat the cost survey over a two-year period every third year. In the next cycle of this cost survey, the cost survey will be mailed in early 2015 to approximately half the population of commercial fishing vessel in the Northeast, sampled by strata, for costs incurred in 2014. Over time, this will enable the SSB to maintain a time series of data for fixed costs and crew payments, improving its ability to perform economic analyses and inform the fisheries management decision making process.

Data on annual costs for vessels that derive 50% or more of their revenue from small-mesh multispecies are limited due to the small percentage of vessels with that level of dependence on small-mesh multispecies as a percentage of their total revenue, and the resulting small numbers of vessels with small-mesh multispecies as the primary species group that were sampled and then returned the annual cost survey for years 2011 and 2012. Therefore, annual cost data from all trawlers is presented below, before turning to a discussion of annual cost data from vessels for which small-mesh multispecies represented the highest percentage of total revenue earned by the vessel by species group.

Table 36 displays the number of vessels in the primary gear group of “trawl” that were sampled for costs incurred in years 2011 and 2012, and the number of surveys that were returned for trawlers. This data is displayed based on vessel length – smaller than or larger than the average trawler in the Northeast commercial fleet, which was 61’ long.

Table 25. Annual cost survey response from vessels with primary gear group “trawl”

STRATA	2011			2012		
	No. Sampled	No. Returned	Response Rate (%)	No. Sampled	No. Returned	Response Rate (%)
Small Trawl	100	28	28.00	112	12	10.71
Large Trawl	101	33	32.67	86	22	25.58

Table 37 presents summary statistics for vessels that responded to the annual cost survey for survey years 2011 and 2012 with primary gear group “trawl”. The total revenue data presented was taken from the Commercial Fisheries Database System, commonly referred to as the "dealer data". The total revenue data presented below does not include any revenue that may have been earned from leasing out quota. Vessel age is calculated based on information from the permit data base. The estimated market value of the vessel was reported by the vessel owner in his or her survey, and includes all equipment, fishing gear, permits and fishing history.

Table 26. Characteristics of trawlers responding to the annual cost survey.

STRATA		n	Mean	Median	Standard Dev	Min	Max
Small Trawl	**Total Revenue ($2013)**	40	$179,156.61	$114,929.46	$174,896.03	$1,107.85	$669,238.28
	Est. Market Value ($2013)	39	$336,883.18	$164,800.00	$421,708.29	$144.20	$1,854,00.00
	Vessel Age (years)	40	31.88	30.00	16.64	6.00	84.00
Large Trawl	**Total Revenue ($2013)**	52	$745,412.57	$692,289.70	$669,433.63	$19,285.72	$3,474,016.96
	Est. Market Value ($2013)	49	$808,321.23	$618,000	$863,502.57	$51,000.00	$5,665,000.00
	Vessel Age (years)	52	33.5	33.00	10.03	12.00	67.00

The re-design of the cost survey instrument attempted to address both the need to distinguish between a true zero cost for a particular category during a given survey year versus non response, and the need to distinguish between typical repair and maintenance costs, and upgrade and improvement costs.

For each cost category, the respondent was given the opportunity to indicate his or her total expenses for that category for the survey year, or check off a box that indicated no costs incurred that year for that category. Nevertheless, some vessel owners may not have indicated when they had a true zero cost for a particular category by checking off the box. If the respondent did not indicate a value for a given cost category and did not check off the box that indicated a true zero cost, a missing value was assumed.

The assignment of expenses to either the repair and maintenance category or to the upgrade and improvement category presented a challenge for survey re-design. Upgrade and improvement expenditures incurred by the vessel owner represent an investment in the capital associated with the fishing vessel, and the annual depreciation of this capital should be accounted for. The re-designed survey instrument asked respondents to allocate expenses to either the repair/maintenance or the upgrade/improvement category. However, results from focus group sessions, during which versions of the survey instrument were pre-tested, suggest that many vessel owners struggle with deciding whether a given expense represents a typical repair or maintenance cost, or an upgrade or improvement cost. Therefore, the survey instrument also asked respondents to describe the upgrade or improvement, and adjustments to the category to which an expense was assigned were made if necessary.

Table 38 presents summary statistics for major cost categories based on expenses reported for 2011 and 2012 by smaller than average and larger than average vessels with primary gear group “trawl”. All costs have been presented in real 2013 U.S. dollars. The major cost categories are repair and maintenance costs, upgrade and improvement costs, fishing business costs, operating (trip) costs and payments to crew, including payments to a hired captain, where applicable. Although 40 smaller than average and 55 larger than average trawl vessels responded to the annual cost survey, not every vessel incurred a cost or indicated zero cost for each of the items included in each major cost category.

Vessel owners were asked to report annual repair and maintenance costs in the following areas: haul out costs (including expenses for taking the vessel out of the water and any transportation costs associated with the haul out), propulsion engine (e.g. engine, drive train, exhaust/cooling systems), deck equipment and other machinery, hull, fishing gear, wheelhouse and electronics (e.g. radar, GPS, VMS, sounder, radio, depth/temperature/net sensors), processing/refrigeration, safety equipment and any other repair and maintenance expenses not included by the sub-categories listed above. Upgrade and improvement costs were also collected for the same categories under that repair and maintenance expenses were collected for; these upgrade and improvement expenses were adjusted for depreciation.

Fishing business costs collected by the annual cost survey for vessels with primary gear group “trawl” in the 2011 and 2012 survey years are also summarized in Table 18. Some of the information collected about fishing business costs by the survey was specific to the vessel for which the vessel owner received a survey. These expenses included mooring/dockage fees, permit and/or license fees, vessel insurance premiums for either hull or protection and indemnity (P&I) insurance, quota or Days-at-Sea (DAS) lease payments, vessel activity or quota monitoring costs (e.g. observer costs), and crew benefits. In addition, information about fishing business overhead costs was collected. These costs include workshop or storage expenses, office expenses, business vehicle usage costs, business travel costs, association fees (e.g., co-operative, fishing organization, sector, and union fees), professional fees (e.g., settlement, accounting and legal fees), principal and interest paid on business loans, advertising costs and costs associated with non-crew labor services (e.g., night watchman and office secretary wages and benefits). These may be spread out among one or more commercial fishing vessels that are owned by the vessel owner. If a vessel owner responding to the survey owned multiple vessels, an approximation was made allocating a portion of these fishing business overhead costs to the vessel for which he or she received an annual cost survey. Not every vessel incurred each one of the expenses included in fishing business costs.

A summary of operating, or trip costs, reported by trawl vessels for survey years 2011 and 2012 is also reported in Table 38. Note that annual operating costs for a particular vessel are expected to vary based on the number of trips taken per year, as well as the type of trips taken by the vessel. Vessel owners were asked to indicate their total operating (trip) expenses for the survey year for the vessel for which they received a survey, including expenses for fuel/oil/filter, ice, fresh water for use in the vessel, general fishing supplies, catch handling (e.g. auction, lumping, grading, shipping and sales representation), communications (not including office phone expenses), general crew supplies, food and drinking, and any other operating costs not covered in the items listed above. A total of 7 vessels (4 smaller than average, 3 larger than average) with primary gear group “trawl” did not report any operating expenses.

The final major cost category represented in Table 38 is total annual payments to crew, including hired captains for trips where the vessel owner was not the vessel operator. Eight small trawl vessels and one large trawl vessel did not report any crew payments.

Table 27. Summary of annual costs by major cost category for vessels responding to the annual cost survey with primary gear group “trawl” (real 2013 U.S. Dollars).

STRATA	Cost Description	n	Mean	Median	Stand Dev	Min	Max
SMALL	**REPAIR/MAINT**	37	$18,782.32	$13,144.14	$16,950.68	$1,184.50	$64,066.00
	UPGRADE/IMP[1]	27	$1,771.96	$872.67	$2,122.94	$72.86	$8,423.11
	FISHING BUSINESS	38	$38,456.65	$28,117.58	$48,869.59	$561.00	$1,461,352.76
	OPERATING (TRIP)	36	$43,407.76	$41,429.175	$31,954.46	$103.00	$127,695.28
	CREW[2]	32	$48,236.00	$32,789.61	$51,028.46	$2,652.00	$226,472.28
LARGE	**REPAIR/MAINT**	52	$74,506.71	$52,157.02	$93,120.27	$5,253.00	$624,972.07
	UPGRADE/IMP[1]	30	$5,289.53	$4,016.55	$4,824.94	$103.00	$17,352.15
	FISHING BUSINESS	37	$138,718.84	$88,827.72	$118,795.61	$510.00	$477,802.58
	OPERATING (TRIP)	49	$305,796.41	$252,269.46	$267,434.10	$875.50	$1,183,470.00
	CREW[2]	51	$215,034.70	$180,243.42	$195,905.21	$214.20	$893,712.46

[1] After adjustment for depreciation.
[2] Includes payment to a hired captain, if applicable.

Five vessels of the 95 vessels (5.26%) that responded to the annual cost survey for costs incurred in 2011 and 2012 with primary gear group “trawl” were identified as small mesh multispecies vessels. A vessel is defined as a small mesh multispecies vessel if small mesh multispecies accounted for the maximum share of the revenue earned by the vessel in that year. No vessels that responded to the survey were identified as small mesh multispecies vessel outside those vessels in the trawl primary gear group.
Table 39 displays the number of small mesh multispecies vessels that were sampled for costs incurred in years 2011 and 2012, and the number of small mesh multispecies vessels that returned the annual cost survey.

Table 28. Annual Cost Survey Responses from Small Mesh Multispecies Vessels.

Survey Year	No. of Vessels Sampled	No. of Returned Surveys	Response Rate (%)
2011	4	3	75.00
2012	9	2	22.22

Due to confidentiality concerns, the remaining tables presenting results obtained from the annual cost survey from small-mesh multispecies vessels will be pooled for the 2011 and 2012 survey years. Table 40 contains summary information about the characteristics of the five small-mesh multispecies vessels that responded to the annual cost survey for either survey year 2011 or 2012. The total revenue data presented was taken from the Commercial Fisheries Database System, commonly referred to as the "dealer data" This does not include revenue that may have been earned by leasing out quota. Vessel age is calculated based on information from the permit data base. The estimated market value of the vessel was reported by the vessel owner in his or her survey, and includes all equipment, fishing gear, permits and fishing history.

Table 29. Characteristics of Small-Mesh Multispecies Vessels Responding to Annual Cost Survey.

	n	Mean	Median	Standard Dev	Min	Max
Total Revenue ($2013)	5	$774,258.87	$241,105.91	$986,628.88		
Est. Market Value ($2013)[1]	5	$493,500.00	$306,000.00	$354,945.42		
Vessel Length (feet)	5	61.98	48.00	22.9	44.00	93.00
Vessel Age (years)	5	34.20	32.00	7.95	26.0	46.0

[1] The vessel owner's report of the estimated market value of the vessel, including all equipment, fishing gear, permits and fishing history, in real 2013 U.S. dollars.

Table 41 presents summary statistics for major costs categories based on expenses reported for 2011 and 2012 by all small-mesh multispecies vessels that responded to the annual cost survey for costs incurred in 2011 and 2012. All costs have been presented in real 2013 U.S. dollars. The major cost categories are repair and maintenance costs, upgrade and improvement costs, fishing business costs, operating (trip) costs and payments to crew, including payments to a hire captain, where applicable. All five small-mesh multispecies vessels responding to the annual cost survey reported repair/maintenance expenses for the survey year, ranging from $2,958.00 to $210,635.00, with a mean value of $76,821.40 Four of the five responding small-mesh multispecies vessels reported upgrade/improvement expenditures. After accounting for depreciation, annual upgrade/improvement expenditures ranged from $4,970.48 to $15,956.83, with an average of $8,698.67. Fishing business costs were reported by four of the five responding small mesh multispecies vessels, with an average annual expense of $75,458.67. All five of the responding small mesh multispecies vessels reported annual operating, or trip, costs; these costs ranged from $45,390 to $1,183,470.00 (the largest amount of annual operating costs reported for a responding vessel with primary gear group trawl), with an average annual operating cost of $493,141,33. However, this average was heavily influenced by the largest annual operating cost reported for these vessels; median reported annual operating cost for these vessels was $69,444.66. All five responding small mesh multispecies vessels reported crew payments, ranging from $5,100.00 to $767,350.00, with an average annual crew payment of $240,189.48.

Table 30. Summary of Annual Costs by Major Cost Category for Small Mesh Multispecies Vessels Responding to the Annual Cost Survey (real 2013 U.S. Dollars).

Cost Description	n	Mean	Median	Stand Dev	Min	Max
REPAIR/MAINT	5	$76,821.40	$58,916.00	$86,059.19	$2,958.00	$210,635.00
UPGRADE/IMP[1]	4	$8,698.67	$6,933.70	$5,074.35	$4,970.48	$15,956.83
FISHING BUSINESS	4	$75,458.67	$40,991.50	$71,263.91	$37,541.66	$182,310.00
OPERATING (TRIP)	5	$493,141.33	$69,444.66	$600,247.28	$45,390.00	$1,183,470.00
CREW[2]	5	$240,189.48	$77,250.00	$317,659.61	$5,100.00	$767,350.00

7.3 Variable Cost Information for Directed Small Mesh Multispecies Trips

Information about some trip costs is collected by observers as part of the Northeast Fishery Observer Program's (NEFOP) data collection effort. The Fisheries Sampling Branch oversees the NEFOP, which collects, processes, and manages the data obtained during commercial fishing trips. Biological and economic data are collected by trained personnel, known as observers, for scientific and management purposes. The economic data are obtained either via personal observation or by interviewing the captain.

Trip cost data collected by observers for a given trip includes tons of ice used during the trip, the price of ice per ton for ice purchased for the trip, the estimated number of gallons of fuel used during the trip, the price per gallon of fuel purchased for the trip, the price of fresh water purchased for the trip (not including drinking water), damage and loss estimates (not including the cost of normal wear and tear), the price paid for supplies purchased for the trip, the price paid for food and drinking water (including the observer's), the price of oil used on the trip, and the price of bait purchased for the trip.

From 1994 to 2013, a total of 439 directed small-mesh multispecies trips were observed, with 28.2% of these trips being multi-day trips. The number of days absent on these trips ranged from 0.15 days to 10.65 days, with an average value of 1.32 days absent and a median value of 0.50 days absent. Prior to 2007, there are years in the time series where very few directed small mesh multispecies were observed. Therefore, summary trip cost data is presented for the 1994-1999 and 2000-2006 periods with the years for each of those periods combined, and then for each year for 2007-2013. Table 42 presents total trip costs per day absent on directed small mesh multispecies trips. All costs have been converted to 2013 real U.S. dollars. No observed directed small mesh multispecies trips reported bait costs, which is consist with the use of trawl gear in this fishery. The total trip costs represented in Table 42 reflect costs for ice, fuel, fresh water for use on the vessel, supplies, food and drinking water, oil, and damage and loss costs. Fuel expenses account for the largest percentage of total trip costs per day absent; in 2013 fuel expenses, on average, were responsible for 80.73% of total trip expenses per day absent on observed directed small mesh multispecies trips. In 2008, the average value of trip costs per day absent spiked due to one vessel that incurred significant damage costs during a directed small mesh multi-species trip.

Table 31. Total Trip Costs Per Day Absent on Directed Small Mesh Multispecies Trips (real 2013 U.S.Dollars).

Time Period	N	Mean	Median	Stand Dev	Min	Max
1994-1999	70	$557.79	$392.99	$857.44	$130.16	$7,243.52
2000-2006	73	$772.11	$607.27	$555.73	$109.66	$2,842.90
2007	15	$1,122.39	$1,127.46	$483.10	$502.03	$1,830.16
2008	10	$3,226.51	$1,347.52	$5,385.28	$963.79	$18,415.93
2009	40	$1,099.62	$972.11	$641.55	$438.91	$3,304.21
2010	53	$1,250.88	$1,082.21	$584.66	$386.27	$3,379.58
2011	46	$1,605.35	$1,328.88	$1,179.93	$383.59	$7,193.82
2012	46	$1,337.25	$1,006.65	$1,176.82	$411.50	$6,342.53
2013	83	$1,191.44	$1,012.34	$709.73	$382.83	$3,648.51

8.0 Small Mesh Multispecies Stock Assessment

8.1 Assessment (Index-Based) and Stock Status Update

Information used in this assessment update includes data from the NEFSC surveys updated through 2017, as well as commercial fishery data from vessel trip reports, dealer landings records and on-board fishery observers updated through 2016. The NEFSC bottom trawl survey switched from the FRV *Albatross IV* to the FSV *Bigelow* in spring 2009. Hence, survey data given here are in "*Albatross IV*" units. Following the accepted index approach from the 2010 benchmark assessment, this assessment update for both stocks of silver hake are based on the three-year moving average of fall survey and exploitation indices for years 2014-2016. For northern red hake, the three-year moving average of the spring survey index for years 2015-2017 and exploitation index for years 2014-2016 were used in this assessment update.

Silver hake

Combined catches of silver hake for both the northern and southern stocks have varied overtime. In the early 2000's catches were approximately 13,000 mt, and then declined to a low of 5,680 mt in 2006. Between 2006 and 2011, catches of silver hake increased to approximately 11,400 mt, and has declined but has remained stable in the recent three years. Majority of the catch has historically come from the southern stock, consisting of up to 89% of the total whiting removal over the last decade. Total catch in the south has been slowly declining in the recent five years while in the north, catches have been steadily increasing. In 2016, northern silver hake catches constituted 47% of total silver hake removals from both stocks. Discards continue to be a small fraction of total removals for both stocks ranging between 6-15% of the total catch (Figure 2).

The three year average fall biomass index for both stocks of silver (19.92 kg/tow in the north vs 1.05 kg/tow in the south) are both above the overfished management threshold (3.21 kg/tow in the north vs 0.83kg/tow in the south). Since 2011, the fall survey biomass for the northern stock has been increasing and currently estimated to be the second highest value in the time series with an average survey mean weight of 21.51kg/tow. The occurrence of several strong year classes in recent years, particularly the 2009 year class (second highest number of age-1 recruits in the time series) coupled with several years of low exploitation rates can be attributed to the recent growth of northern hake stock. In contrast, the fall survey biomass index for southern stock of hake has been declining since 2010 and approaching the management threshold. Recruitment trends in the southern stock of hake have been poor and estimated to be below average since 2014. The exploitation index measured as the ratio of total catch to the fall survey biomass has remained consistently low relative to historical years for both stocks and well below (0.15 kt/kg in the north vs 2.95 kt/kg in the south) the management thresholds (2.78 kt/kg in the north vs 34.17 kt/kg in the south). Based on the existing reference points from the last benchmark assessment (NEFSC 2010), it is recommended that both stocks of silver hake are not overfished and overfishing is not occurring (Table 43 and Table 44; Figure 24**,** Figure 25 and Figure 26Figure 34).

Red hake

The recent three-year arithmetic mean biomass index based on the NEFSC spring bottom trawl survey for the northern stock has been increasing in recent years and estimated at 5.13 kg/tow in 2017, four times above the management threshold (1.27 kg/tow). In the south, the NEFSC spring bottom trawl survey however has been declining since 2011. The recent three-year mean biomass index from the NEFSC spring survey for the southern red hake stock (2015-2017 = 0.38 kg/tow) is below the southern management threshold (0.51 kg/tow) and represents a change in the biomass stock status from the previous assessment update from not overfished to overfished. The exploitation index measured as the ratio of total catch to the NEFSC spring bottom trawl survey mean biomass index in the north (0.09 kg/kt) is below the management threshold (0.163 kg/kt) and above in the south. The 2016 southern red hake exploitation index was estimated at 4.03 kg/kt, 33% above the southern management threshold for red hake (3.038 kg/kt). Based on the existing reference points from the last benchmark assessment (NEFSC 2010), it is recommended that Northern stock of red hake is not overfished and overfishing is not occurring. In the south, the stock is overfished and overfishing is occurring. (Table 45 and Table 46**;** Figure 27**,** Figure 28 and Figure 29).

Table 32. Northern silver hake - Summary of total catch (kt), NEFSC fall survey biomass in albatross units (kg/tow) and index of relative exploitation ratios of total catch to the fall survey biomass (kt/kg) for northern silver hake. Note: This assessment update was based on the most recent three year average of both the NEFSC fall survey biomass the relative exploitation ratio from 2014-2016.

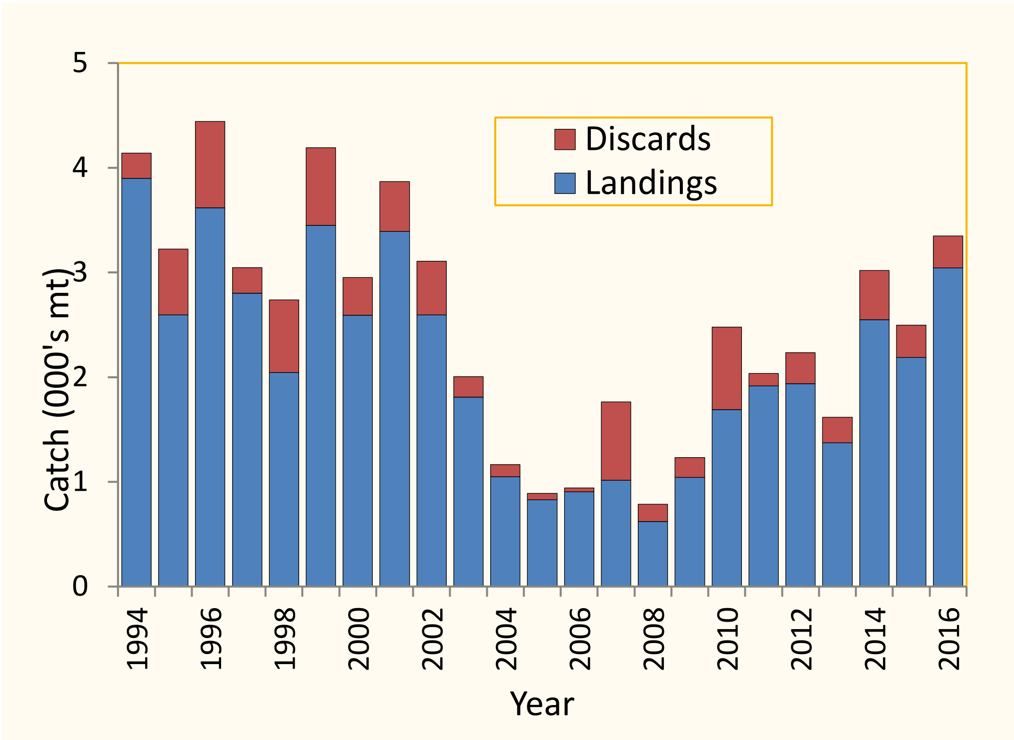
Year	Northern Fall Survey Arithmetic kg/tow	Northern Fall Survey 3-year Average	Northern Total Landings (000's mt)	Northern Discards (000's mt)	Northern Total Catch (000's mt)	Northern Exploitation Index (kg/000's mt)	Northern Exploitation Index 3-year Average
1955			53.36		53.36		
1956			42.15		42.15		
1957			62.75		62.75		
1958			49.90		49.90		
1959			50.61		50.61		
1960			45.54		45.54		
1961			39.69		39.69		
1962			79.00		79.00		
1963	23.10		73.92		73.92	3.20	
1964	4.34		94.46		94.46	21.77	
1965	7.06	11.50	45.28		45.28	6.41	10.46
1966	4.19	5.20	47.81		47.81	11.41	13.20
1967	2.27	4.51	33.37		33.37	14.70	10.84
1968	2.28	2.91	41.38		41.38	18.15	14.75
1969	2.41	2.32	24.06		24.06	9.98	14.28
1970	3.03	2.57	27.53		27.53	9.09	12.41
1971	2.67	2.70	36.40		36.40	13.63	10.90
1972	5.78	3.83	25.22		25.22	4.36	9.03
1973	4.12	4.19	32.09		32.09	7.79	8.60
1974	3.45	4.45	20.68		20.68	5.99	6.05
1975	8.09	5.22	39.87		39.87	4.93	6.24
1976	11.25	7.60	13.63		13.63	1.21	4.05
1977	6.72	8.69	12.46		12.46	1.85	2.66
1978	6.32	8.10	12.61		12.61	2.00	1.69
1979	6.18	6.41	3.42		3.42	0.55	1.47
1980	7.23	6.58	4.73		4.73	0.65	1.07
1981	4.52	5.98	4.42	2.64	7.05	1.56	0.92
1982	6.28	6.01	4.66	2.91	7.57	1.21	1.14
1983	8.76	6.52	5.31	2.64	7.95	0.91	1.22
1984	3.36	6.13	8.29	2.59	10.88	3.24	1.78
1985	8.28	6.80	8.30	2.56	10.86	1.31	1.82
1986	13.04	8.23	8.50	2.35	10.86	0.83	1.79
1987	9.79	10.37	5.66	2.11	7.77	0.79	0.98
1988	6.05	9.63	6.79	1.79	8.57	1.42	1.01
1989	10.53	8.79	4.65	2.32	6.96	0.66	0.96
1990	15.61	10.73	6.38	1.96	8.34	0.53	0.87
1991	10.52	12.22	6.06	1.26	7.31	0.69	0.63
1992	10.25	12.13	5.31	1.42	6.73	0.66	0.63
1993	7.50	9.42	4.36	0.69	5.05	0.67	0.67
1994	6.84	8.20	3.90	0.24	4.14	0.61	0.65
1995	12.89	9.08	2.59	0.63	3.22	0.25	0.51
1996	7.57	9.10	3.62	0.82	4.44	0.59	0.48
1997	5.66	8.71	2.80	0.24	3.05	0.54	0.46
1998	18.91	10.71	2.05	0.69	2.74	0.14	0.42
1999	11.15	11.91	3.45	0.74	4.19	0.38	0.35

Year	Northern Fall Survey Arithmetic kg/tow	Northern Fall Survey 3-year Average	Northern Total Landings (000's mt)	Northern Discards (000's mt)	Northern Total Catch (000's mt)	Northern Exploitation Index (kg/000's mt)	Northern Exploitation Index 3-year Average
2000	13.51	14.52	2.59	0.36	2.95	0.22	0.25
2001	8.33	11.00	3.39	0.48	3.87	0.46	0.35
2002	7.99	9.94	2.59	0.51	3.11	0.39	0.36
2003	8.29	8.20	1.81	0.20	2.01	0.24	0.37
2004	3.28	6.52	1.05	0.12	1.16	0.35	0.33
2005	1.72	4.43	0.83	0.06	0.89	0.52	0.37
2006	3.69	2.90	0.90	0.04	0.94	0.26	0.38
2007	6.44	3.95	1.01	0.75	1.76	0.27	0.35
2008	5.27	5.13	0.62	0.17	0.79	0.15	0.23
2009	6.89	6.20	1.04	0.19	1.23	0.18	0.20
2010	13.35	8.50	1.69	0.79	2.48	0.19	0.17
2011	9.97	10.07	1.93	0.12	2.04	0.20	0.19
2012	20.43	14.58	1.95	0.29	2.24	0.11	0.17
2013	16.75	15.72	1.37	0.25	1.62	0.10	0.14
2014	18.77	18.65	2.55	0.47	3.02	0.16	0.12
2015	19.49	18.34	2.19	0.31	2.50	0.13	0.13
2016	21.51	19.92	3.07	0.31	3.37	0.16	0.15

Table 33. Southern silver hake - Summary of total catch (kt), NEFSC fall survey biomass in albatross units (kg/tow) and index of relative exploitation ratios of total catch to the fall survey biomass (kt/kg) for southern silver hake. Note: This assessment update was based on the most recent three year average of both the NEFSC fall survey biomass the relative exploitation ratio from 2014-2016.

Year	Southern Fall Survey Arithmetic kg/tow	Southern Fall Survey 3-year Average	Southern Total Landings (000's mt)	Southern Discards (000's mt)	Southern Total Catch (000's mt)	Southern Exploitation Index (kg/000's mt)	Southern Exploitation Index 3-year Average
1955			13.26		13.26		
1956			14.24		14.24		
1957			16.43		16.43		
1958			12.90		12.90		
1959			16.39		16.39		
1960			8.82		8.82		
1961			12.65		12.65		
1962			17.94		17.94		
1963	4.66		89.43		89.43	19.19	
1964	4.06		147.05		147.05	36.22	
1965	5.28	4.67	294.12		294.12	55.70	37.04
1966	2.64	3.99	202.32		202.32	76.64	56.19
1967	2.44	3.45	87.38		87.38	35.81	56.05
1968	2.73	2.60	58.16		58.16	21.30	44.58
1969	1.26	2.14	74.89		74.89	59.44	38.85
1970	1.35	1.78	26.83		26.83	19.87	33.54
1971	2.21	1.61	70.51		70.51	31.90	37.07
1972	2.13	1.90	88.18		88.18	41.40	31.06
1973	1.70	2.01	102.08		102.08	60.05	44.45
1974	0.85	1.56	102.40		102.40	120.47	73.97
1975	1.79	1.45	72.16		72.16	40.31	73.61
1976	1.99	1.54	64.61		64.61	32.47	64.42
1977	1.68	1.82	57.16		57.16	34.02	35.60
1978	2.50	2.06	25.83		25.83	10.33	25.61
1979	1.68	1.95	16.40		16.40	9.76	18.04
1980	1.63	1.94	11.68		11.68	7.17	9.09
1981	1.12	1.48	13.43	3.50	16.93	15.12	10.68
1982	1.56	1.44	14.15	4.65	18.80	12.05	11.44
1983	2.57	1.75	11.86	4.81	16.67	6.49	11.22
1984	1.40	1.84	12.96	4.88	17.84	12.74	10.43
1985	3.55	2.51	12.82	3.87	16.69	4.70	7.98
1986	1.45	2.13	9.70	4.33	14.03	9.68	9.04
1987	1.95	2.32	9.55	4.25	13.80	7.08	7.15
1988	1.78	1.73	8.95	4.50	13.45	7.56	8.10
1989	1.87	1.87	13.00	6.57	19.57	10.47	8.37
1990	1.52	1.72	13.02	5.97	18.99	12.49	10.17
1991	0.85	1.41	9.74	3.08	12.82	15.08	12.68
1992	0.99	1.12	10.53	3.45	13.98	14.12	13.90
1993	1.28	1.04	12.49	5.17	17.66	13.80	14.33
1994	0.79	1.02	12.18	5.94	18.12	22.94	16.95
1995	1.59	1.22	11.99	1.40	13.39	8.42	15.05
1996	0.45	0.94	12.13	0.48	12.61	28.02	19.79
1997	0.83	0.96	12.55	0.62	13.17	15.87	17.44
1998	0.57	0.62	12.56	0.53	13.09	22.96	22.28
1999	0.82	0.74	10.42	3.55	13.97	17.04	18.62

Year	Southern Fall Survey Arithmetic kg/tow	Southern Fall Survey 3-year Average	Southern Total Landings (000's mt)	Southern Discards (000's mt)	Southern Total Catch (000's mt)	Southern Exploitation Index (kg/000's mt)	Southern Exploitation Index 3-year Average
2000	0.72	0.70	9.47	0.33	9.80	13.61	17.87
2001	2.04	1.19	8.88	0.19	9.07	4.45	11.70
2002	1.18	1.31	4.89	0.41	5.30	4.49	7.52
2003	1.42	1.55	6.28	0.60	6.88	4.85	4.59
2004	1.24	1.28	6.97	1.20	8.17	6.59	5.31
2005	0.94	1.20	6.40	1.58	7.98	8.49	6.64
2006	1.42	1.20	4.58	0.16	4.74	3.34	6.14
2007	0.87	1.08	5.07	0.15	5.22	6.00	5.94
2008	1.36	1.22	5.58	1.03	6.61	4.86	4.73
2009	1.10	1.11	6.75	0.84	7.59	6.90	5.92
2010	2.82	1.76	6.39	0.78	7.17	2.54	4.77
2011	1.77	1.90	5.75	1.81	7.56	4.27	4.57
2012	1.98	2.19	5.43	1.02	6.45	3.25	3.35
2013	1.33	1.70	4.79	0.64	5.42	4.07	3.86
2014	1.44	1.58	4.71	0.66	5.37	3.74	3.69
2015	0.42	1.06	4.26	0.29	4.56	10.87	6.22
2016	1.30	1.05	3.29	0.54	3.83	2.95	5.85



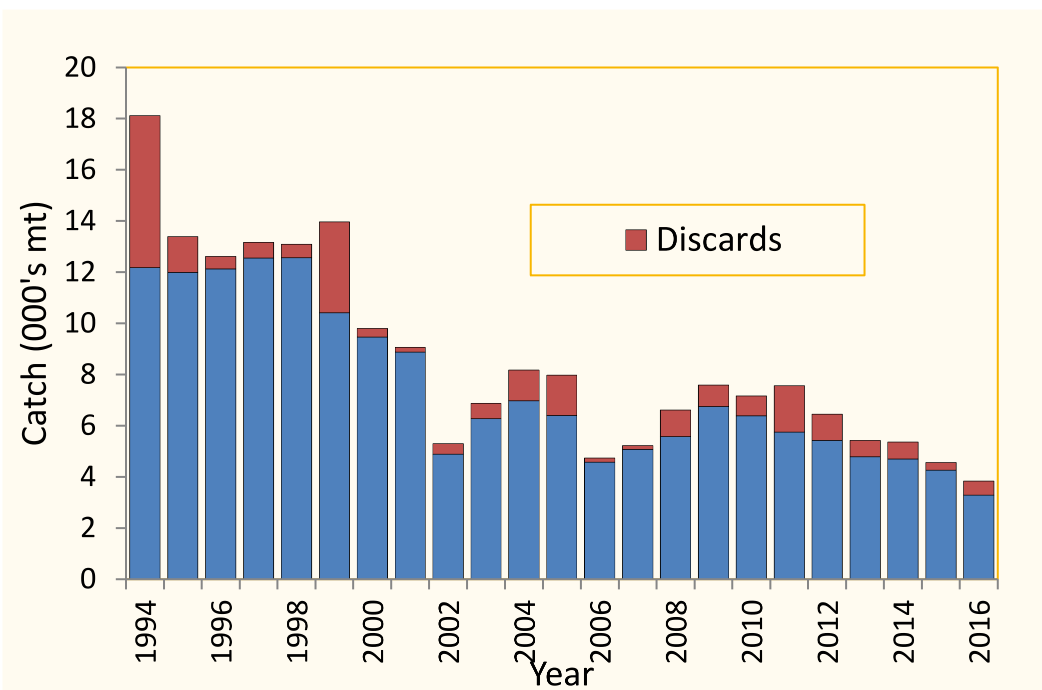


Figure 7: Calendar year total catch of Silver hake from the Northern (TOP) and Southern (BOTTOM) stock from 1994-2016

Figure 8. Northern Silver hake fall survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the fall survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 23 years of the entire time series.

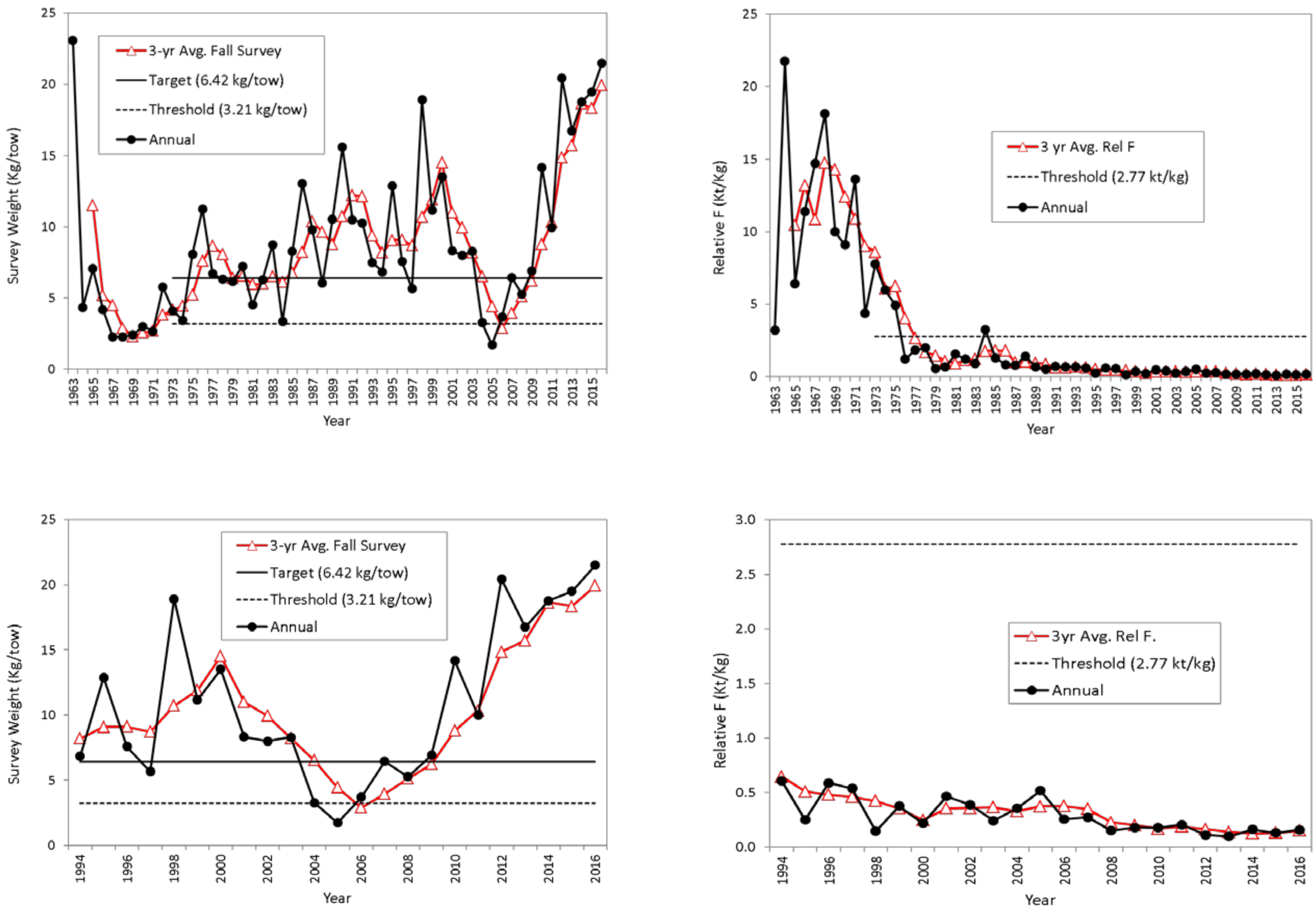


Figure 9. Southern silver hake fall survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the fall survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 23 years of the entire time series

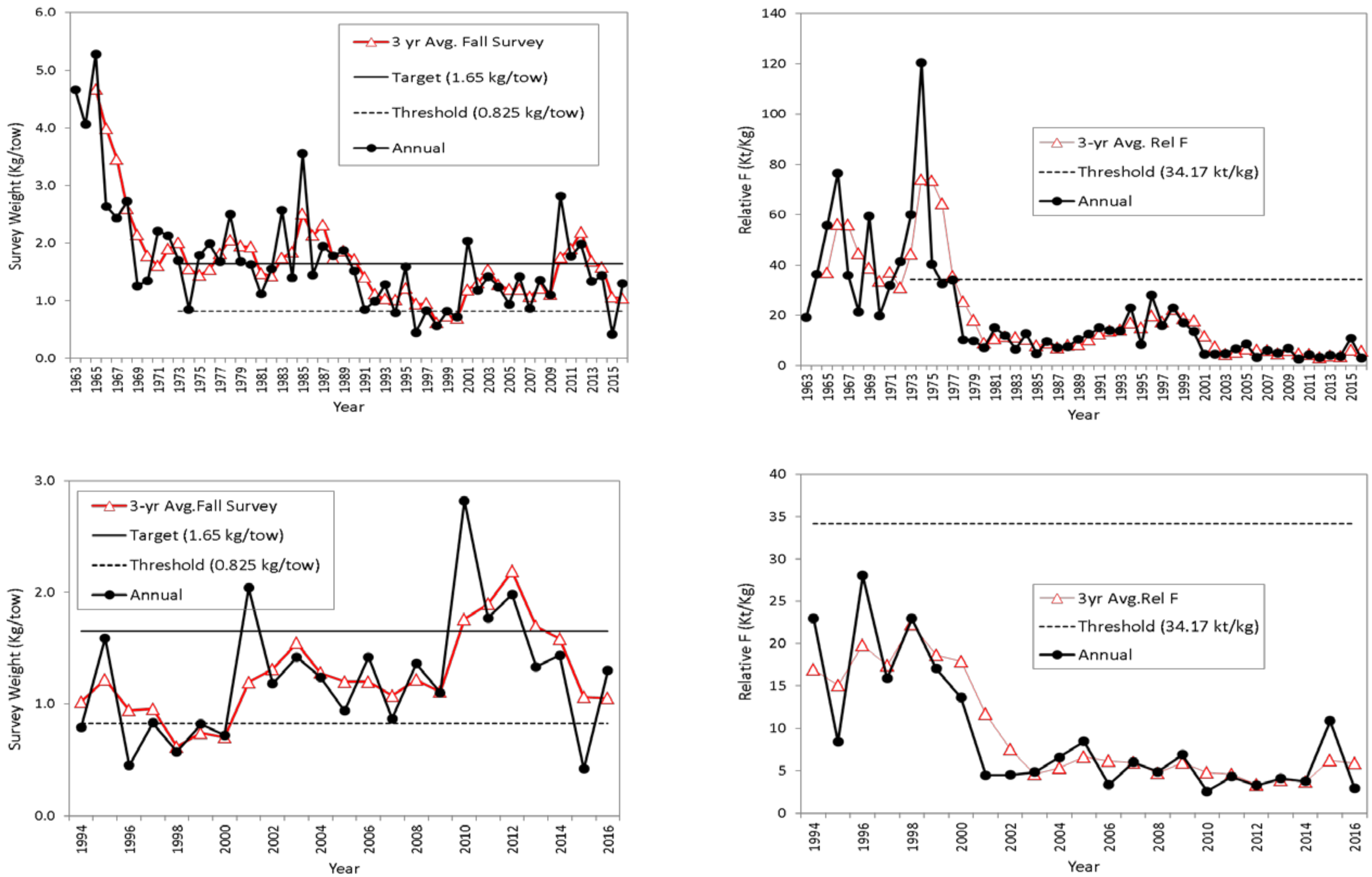


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Figure 10. Silver hake biomass and fishing stock status plots for specification years 2015-2017 (labeled as 2014) and 2018-2020 (labeled as 2017) and associated confidence intervals. The circle symbols are points estimates derived from the ratio of the most recent 3yr average index to proxy reference points while the 90% CI were calculated from the 5th and 95th percentile of the cumulative distribution of the recent 3year index of biomass and Relative F.

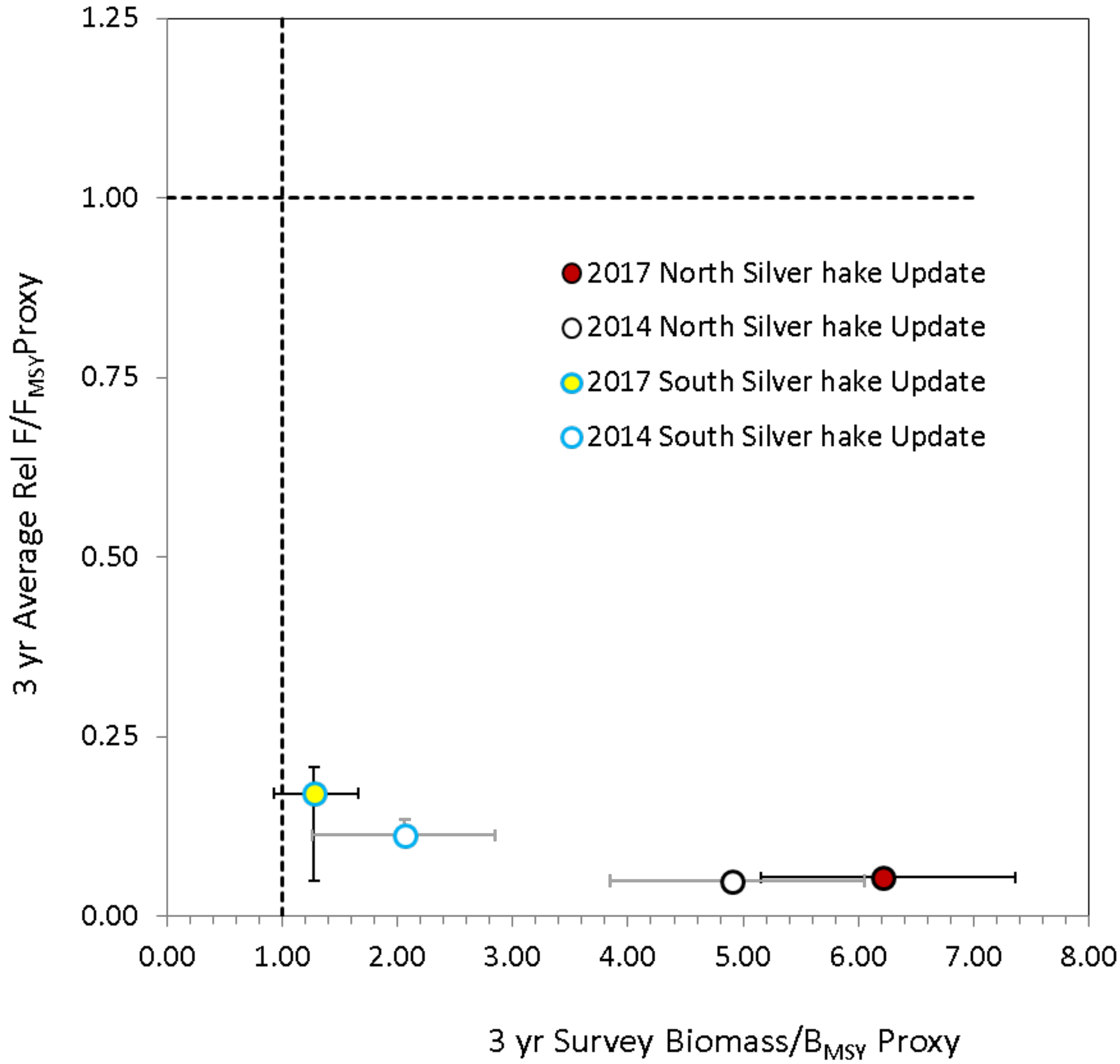


Table 34. Northern red hake - Summary of total catch (kt), NEFSC spring survey biomass in albatross units (kg/tow) and index of relative exploitation ratios of total catch to the spring survey biomass (kt/kg) for northern red hake. Note: This assessment update was based on the most recent three year average of both the spring survey biomass (2015-2017) and the relative exploitation ratios from 2014-2016.

Year	Northern Spring Survey arithmetic (kg/tow)	Northern Spring Survey 3-year Average (kg/tow)	Total Northern Commercial Landings (000's mt)	Northern Commercial Discards (000's mt)	Northern Recreational Catch (000's mt)	Northern total Catch (000's mt)	Northern Exploitation Index (kg/000's mt)	Northern Exploitation Index 3-year Average (kg/000's mt)
1955								
1956								
1957								
1958								
1959								
1960								
1961								
1962			1.91	1.60	0.007	3.52		
1963			3.28	1.60	0.004	4.89		
1964			1.41	1.70	0.001	3.11		
1965			2.77	1.62	0.001	4.40		
1966			5.58	1.60	0.003	7.18		
1967			1.86	1.40	0.002	3.27		
1968	1.14		2.63	1.30	0.002	3.93	3.45	
1969	0.64		2.02	1.12	0.001	3.14	4.91	
1970	0.54	0.77	1.03	1.10	0.001	2.13	3.94	4.10
1971	0.65	0.61	4.81	1.16	0.001	5.97	9.21	6.02
1972	1.56	0.92	15.03	0.96	0.002	15.99	10.25	7.80
1973	4.31	2.17	15.29	0.91	0.001	16.20	3.76	7.74
1974	2.43	2.77	7.22	0.82	0.003	8.04	3.31	5.77
1975	4.25	3.67	8.70	1.20	0.002	9.90	2.33	3.13
1976	3.37	3.35	6.34	0.93	0.002	7.26	2.15	2.60
1977	2.66	3.43	0.89	1.08	0.003	1.98	0.74	1.74
1978	2.57	2.87	1.22	1.12	0.004	2.34	0.91	1.27
1979	2.04	2.42	1.52	1.22	0.006	2.75	1.35	1.00
1980	3.88	2.83	1.03	1.37	0.004	2.40	0.62	0.96
1981	6.35	4.09	1.25	1.32	0.031	2.60	0.41	0.79
1982	2.13	4.12	1.21	1.46	0.003	2.67	1.26	0.76
1983	3.70	4.06	0.90	1.35	0.000	2.25	0.61	0.76
1984	2.98	2.94	1.06	1.33	0.001	2.39	0.80	0.89
1985	3.91	3.53	0.99	1.27	0.000	2.26	0.58	0.66
1986	3.26	3.39	1.46	1.19	0.000	2.65	0.81	0.73
1987	2.94	3.37	1.01	1.05	0.000	2.07	0.70	0.70
1988	2.00	2.73	0.86	0.90	0.004	1.76	0.88	0.80
1989	1.65	2.20	0.78	1.45	0.000	2.22	1.35	0.98
1990	1.33	1.66	0.83	0.60	0.004	1.43	1.07	1.10
1991	1.62	1.53	0.74	0.82	0.002	1.56	0.96	1.13
1992	2.50	1.82	0.92	0.73	0.001	1.65	0.66	0.90
1993	2.82	2.32	0.77	0.08	0.001	0.85	0.30	0.64
1994	1.59	2.31	0.73	0.08	0.002	0.81	0.51	0.49
1995	1.97	2.13	0.19	0.06	0.001	0.25	0.13	0.31
1996	1.79	1.79	0.41	0.66	0.005	1.07	0.60	0.41
1997	1.81	1.86	0.34	0.13	0.001	0.46	0.26	0.33
1998	2.52	2.04	0.19	0.13	0.000	0.32	0.13	0.33
1999	2.32	2.22	0.22	0.47	0.000	0.69	0.30	0.23
2000	3.19	2.68	0.20	0.06	0.000	0.25	0.08	0.17

Year	Northern Spring Survey arithmetic (kg/tow)	Northern Spring Survey 3-year Average (kg/tow)	Total Northern Commercial Landings (000's mt)	Northern Commercial Discards (000's mt)	Northern Recreational Catch (000's mt)	Northern total Catch (000's mt)	Northern Exploitation Index (kg/000's mt)	Northern Exploitation Index 3-year Average (kg/000's mt)
2001	3.58	3.03	0.22	0.14	0.000	0.36	0.10	0.16
2002	4.46	3.74	0.28	0.10	0.000	0.38	0.08	0.09
2003	1.00	3.01	0.21	0.09	0.000	0.30	0.30	0.16
2004	1.77	2.41	0.10	0.06	0.000	0.16	0.09	0.16
2005	1.10	1.29	0.10	0.06	0.000	0.15	0.14	0.18
2006	0.91	1.26	0.10	0.18	0.001	0.28	0.30	0.18
2007	2.06	1.36	0.07	0.13	0.000	0.20	0.10	0.18
2008	3.49	2.15	0.05	0.06	0.000	0.11	0.03	0.14
2009	1.78	2.44	0.09	0.10	0.002	0.18	0.10	0.08
2010	2.79	2.69	0.07	0.24	0.001	0.31	0.11	0.08
2011	2.18	2.25	0.14	0.10	0.001	0.24	0.11	0.11
2012	1.73	2.23	0.10	0.19	0.001	0.29	0.17	0.13
2013	1.35	1.75	0.10	0.22	0.003	0.31	0.23	0.17
2014	3.02	2.03	0.07	0.19	0.012	0.27	0.09	0.16
2015	6.27	3.55	0.10	0.27	0.002	0.37	0.06	0.13
2016	4.46	4.58	0.14	0.26	0.003	0.41	0.09	0.08
2017	4.66	5.13						

Table 35. Southern red hake - Summary of total catch (kt), NEFSC spring survey biomass in albatross units (kg/tow) and index of relative exploitation ratios of total catch to the spring survey biomass (kt/kg) for southern red hake. Note: This assessment update was based on the most recent three year average of both the spring survey biomass (2015-2017) and the relative exploitation ratios from 2014-2016

Year	Southern Spring Survey arithmetic kg/tow	Southern Spring Survey 3-year Average kg/tow	Total Southern Commercial Landings (000's mt)	Southern Commercial Discards (000's mt)	Southern Recreational Catch (000's mt)	Southern total Catch (000's mt)	Southern Exploitation Index (kg/000's mt)	Southern Exploitation Index 3-year Average (kg/000's mt)
1955								
1956								
1957								
1958								
1959								
1960								
1961								
1962			11.87	4.00	0.892	16.76		
1963			31.90	4.00	0.770	36.67		
1964			43.37	3.76	0.848	47.98		
1965			92.99	4.29	0.634	97.92		
1966			107.92	3.77	0.094	111.79		
1967			58.78	3.66	0.165	62.61		
1968	1.29		18.14	3.72	0.575	22.43	17.45	
1969	1.08		52.93	3.62	0.489	57.04	52.72	
1970	1.72	1.36	11.45	3.14	0.410	15.01	8.71	26.29
1971	3.49	2.10	35.13	2.31	0.287	37.73	10.82	24.08
1972	3.59	2.93	61.19	2.10	0.177	63.47	17.68	12.40
1973	3.99	3.69	51.36	2.24	0.317	53.92	13.51	14.00
1974	2.84	3.47	26.64	2.16	0.191	28.99	10.22	13.80
1975	3.18	3.34	19.98	1.76	0.052	21.79	6.85	10.19
1976	5.31	3.78	22.47	1.83	0.645	24.94	4.69	7.25
1977	2.30	3.60	7.06	1.82	0.750	9.63	4.19	5.24
1978	7.65	5.09	5.46	2.44	0.971	8.87	1.16	3.35
1979	1.51	3.82	7.59	2.67	0.245	10.50	6.94	4.09
1980	2.38	3.85	4.08	2.70	0.144	6.93	2.91	3.67
1981	4.61	2.84	2.32	2.72	0.176	5.21	1.13	3.66
1982	3.34	3.45	3.17	3.78	0.029	6.98	2.09	2.04
1983	2.21	3.39	1.44	3.89	0.135	5.47	2.48	1.90
1984	1.33	2.29	1.27	3.91	0.548	5.73	4.30	2.96
1985	1.39	1.64	0.90	2.97	0.029	3.90	2.80	3.19
1986	1.73	1.49	0.69	3.39	0.205	4.29	2.47	3.19
1987	0.88	1.33	0.94	3.31	0.472	4.73	5.38	3.55
1988	1.01	1.21	0.87	3.46	0.251	4.58	4.56	4.14
1989	0.49	0.79	0.93	5.01	0.436	6.37	13.09	7.68
1990	0.71	0.73	0.80	4.75	0.514	6.06	8.57	8.74
1991	0.61	0.60	0.93	2.61	0.285	3.82	6.26	9.30
1992	0.47	0.59	1.25	6.34	0.194	7.78	16.74	10.52
1993	0.42	0.50	0.92	5.31	0.089	6.32	14.91	12.63
1994	0.68	0.52	0.98	1.72	0.069	2.77	4.11	11.92
1995	0.52	0.54	1.43	1.33	0.045	2.80	5.43	8.15
1996	0.45	0.55	0.70	0.38	0.019	1.10	2.43	3.99
1997	1.16	0.71	1.00	2.42	0.173	3.59	3.10	3.65
1998	0.21	0.61	1.15	0.74	0.053	1.95	9.10	4.87
1999	0.46	0.61	1.35	1.06	0.053	2.46	5.42	5.87
2000	0.42	0.36	1.42	0.25	0.044	1.71	4.04	6.19

Year	Southern Spring Survey arithmetic kg/tow	Southern Spring Survey 3-year Average kg/tow	Total Southern Commercial Landings (000's mt)	Southern Commercial Discards (000's mt)	Southern Recreational Catch (000's mt)	Southern total Catch (000's mt)	Southern Exploitation Index (kg/000's mt)	Southern Exploitation Index 3-year Average (kg/000's mt)
2001	0.64	0.51	1.47	0.14	0.024	1.63	2.54	4.00
2002	0.54	0.54	0.66	0.33	0.010	1.00	1.85	2.81
2003	0.21	0.46	0.62	0.35	0.018	0.99	4.79	3.06
2004	0.15	0.30	0.59	0.62	0.015	1.22	7.92	4.85
2005	0.38	0.25	0.36	1.01	0.118	1.48	3.94	5.55
2006	0.38	0.30	0.38	0.67	0.077	1.13	2.96	4.94
2007	0.86	0.54	0.47	1.55	0.151	2.17	2.53	3.14
2008	0.47	0.57	0.58	0.81	0.117	1.51	3.19	2.90
2009	1.44	0.92	0.58	0.87	0.133	1.58	1.10	2.27
2010	0.94	0.95	0.58	0.74	0.153	1.47	1.56	1.95
2011	1.79	1.39	0.50	1.01	0.094	1.60	0.89	1.18
2012	1.06	1.26	0.75	0.65	0.085	1.49	1.40	1.29
2013	0.64	1.16	0.44	0.58	0.143	1.16	1.82	1.37
2014	0.63	0.78	0.56	0.52	0.089	1.16	1.85	1.69
2015	0.58	0.62	0.39	0.85	0.027	1.26	2.17	1.95
2016	0.31	0.51	0.39	0.76	0.130	1.28	4.13	2.72
2017	0.25	0.38						

Figure 11. Northern Red hake spring survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the spring survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 24 years of the entire time series.

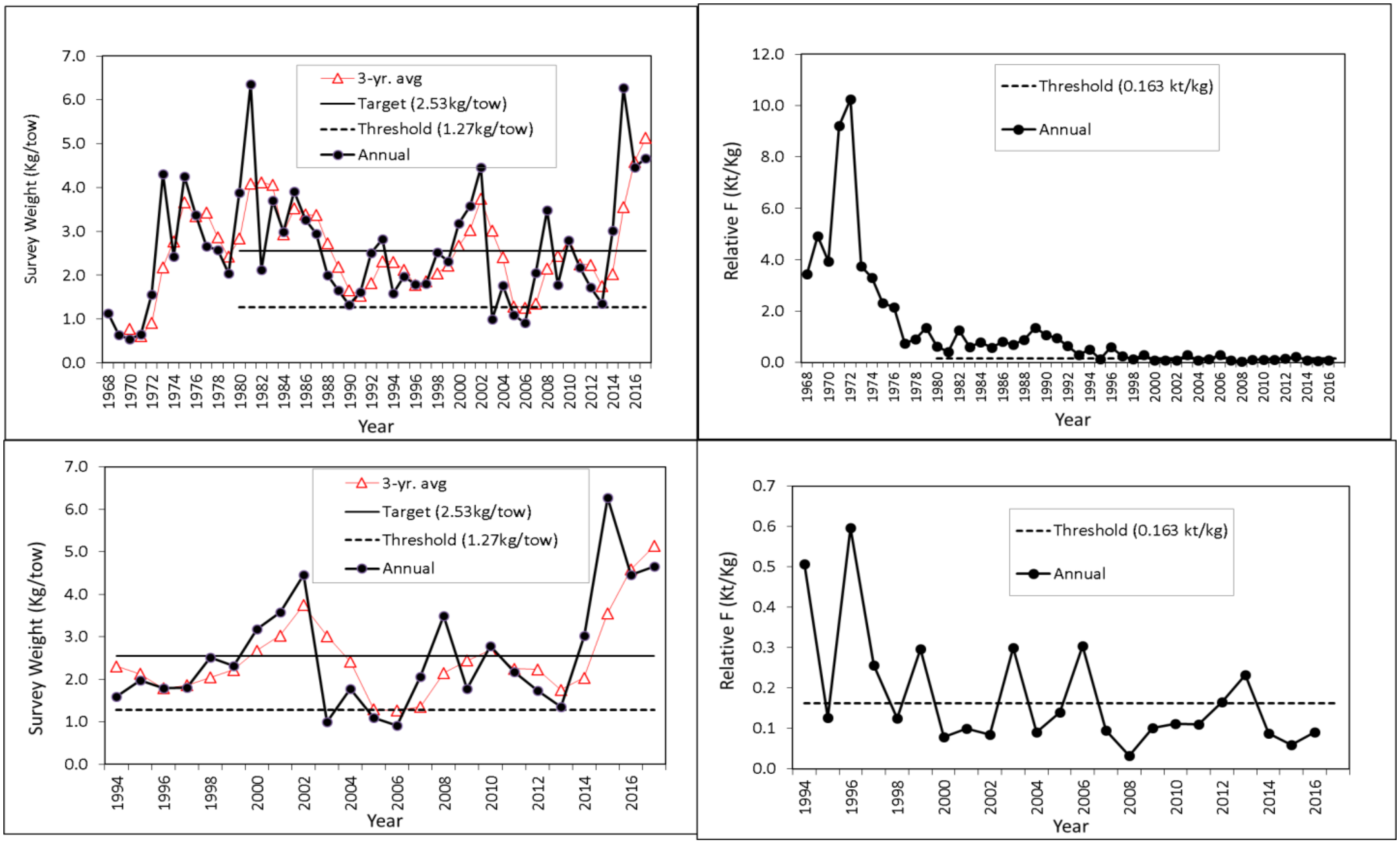


Figure 12. Southern red hake spring survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the spring survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 24 years of the entire time series.

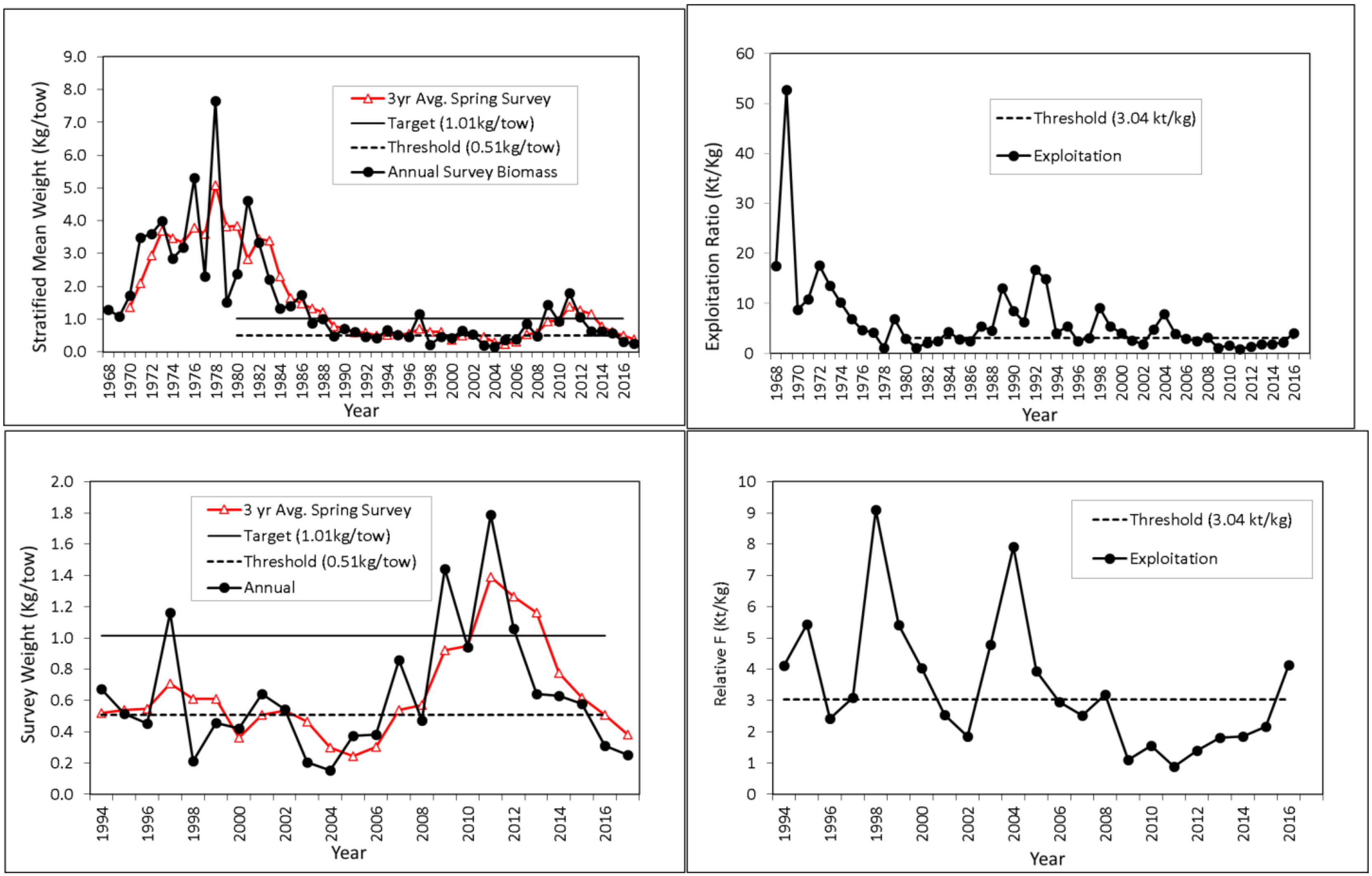
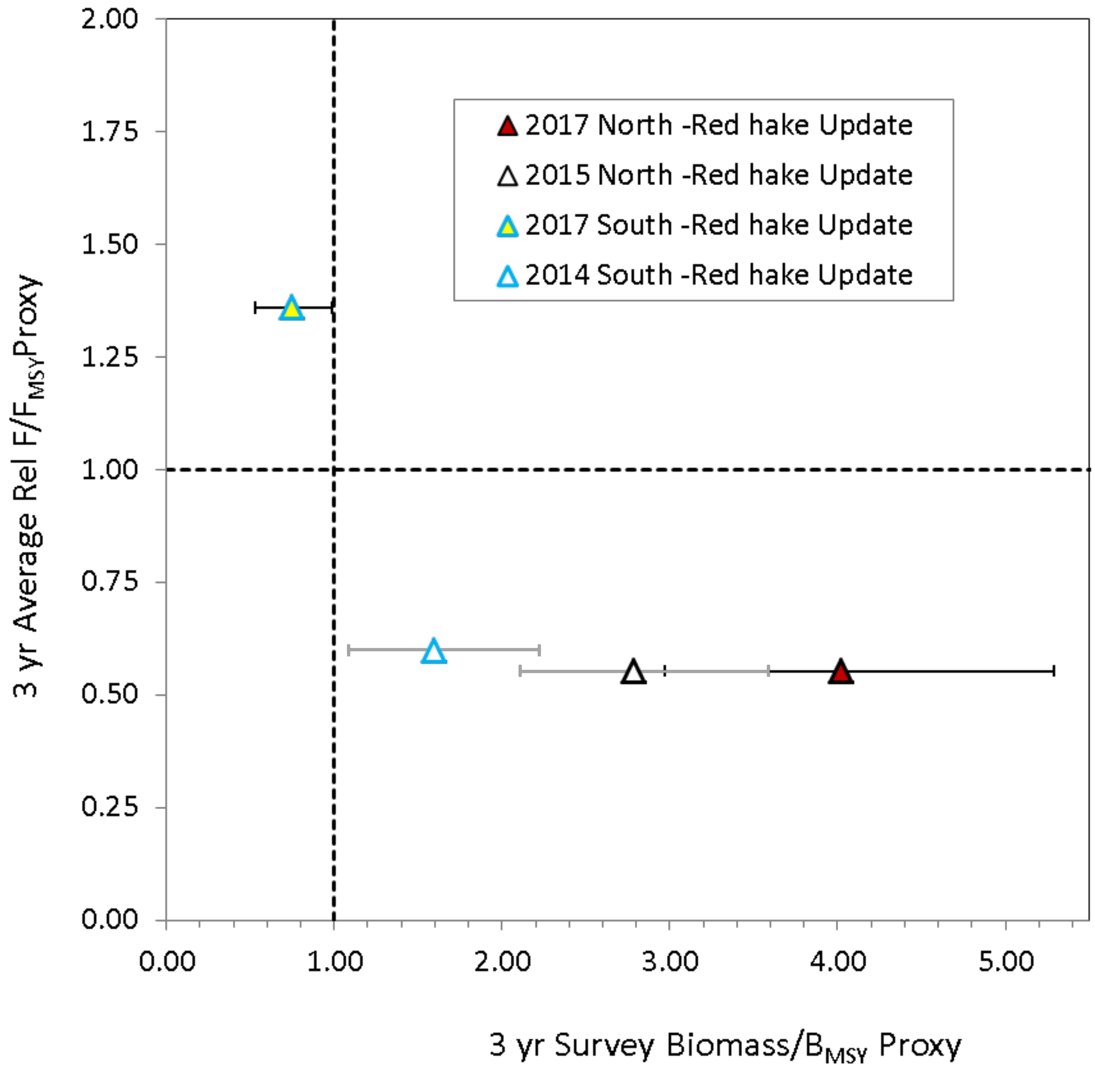


Figure 13. Red hake biomass and fishing stock status plots for specification years 2016-2018 in the north (labeled as 2015), 2015-2017 in the south (labeled as 2014) and 2018-2020 (labeled as 2017) and associated 95% confidence intervals. The triangle symbols are points estimates derived from the ratio of the most recent 3yr average index to proxy reference points while the 95% CI were calculated from the 5th and 95th percentile of the cumulative distribution of the recent 3year index of biomass and Relative F.



8.2 Overfishing Limit (OFL) and Allowable Biological Catch (ACL)

The overfishing limit (OFL) as adopted in amendment 19 is an annual limit derived as the product of current population biomass and fishing rate that will produce the long-term sustainable maximum yield, after taking into account the variance for each factor.
Uncertainty in the silver hake OFL was estimated as a joint product of the probability distribution between the F_{MSY} proxy and the most recent 3-year average of the fall survey biomass (2014-2016) while red hake used the 3-year average spring survey biomass (2015-2017) from the bottom trawl survey applied to F_{MSY} proxy. It should be noted that the variance for the survey indices explicitly incorporates the Bigelow conversion coefficients and associated standard errors from the calibration experiment (**Miller et al. 2010**) to approximate the Albatross variance equivalent based on the following relationship:

$$V(I_{survey}) = \left[\frac{V\left[\frac{I_{HBB}^{yr1}}{\rho}\right] + V\left[\frac{I_{HBB}^{yr2}}{\rho}\right] + V\left[\frac{I_{HBB}^{yr3}}{\rho}\right]}{3} \right]$$

The variance for the observed indices for each year and vessel was estimated from the expected values $E(I_{vessel}^{yr})$ of the stratified mean weight (kg/tow) and the observed coefficient of variance (CV) as:

$$V(I_{vessel}^{yr}) = (CV * E(I))^2$$

The variances for the Henry B. Bigelow survey indices, calibrated to Albatross IV units (Miller et al 2010) by applying the conversion coefficient (ρ), were estimated using Taylor series expansion in the following relationship:

$$V(I_{HBB \to ALB}^{yr1-yr3}) = \left(\frac{I_{HB}^{yr}}{\rho}\right)^2 \times \left[\frac{V(I_{HB}^{yr})}{(I_{HB}^{yr})^2} + \frac{V(\rho)}{\rho^2}\right]$$

Although survey mean weights were estimated from a length-based based model, the standard errors were derived from the constant model as a proxy for the length-based estimates due to unavailable variance estimates for the length-based calibration approach. A comparison of the aggregated survey mean weights between the length-based and constant model approach showed minimal differences, therefore, the application of the variance from the constant model was assumed to be a reasonable approximation for the length-based model.

Silver hake probability distributions for F_{msy} proxy were derived from a lognormal distribution of the mean and variance for year 1973-1982. Preliminary attempts assumed a normal distribution of the mean FMSY proxy, however the distribution was deemed less desirable due to the high variability of silver hake catches dominated by the distant-water fleets during the period used to define FMSY proxy. Consequently, this resulted in negative catches in the OFL distribution, and was not considered in this assessment update.

Although red hake does not have an accepted analytical model from the previous benchmark assessment, the SARC agreed to use the relative F (RelF) from the AIM analysis strictly as a proxy F_{msy} For red hake (**NEFSC, 2011**). The probability distribution for F_{msy} proxy was obtained from the AIM bootstrap distribution. For each bootstrap calculation, the saved predicted values of the Ln (replacement ratio) and random residuals from the initial regression of the replacement ratio and the RelF estimates are passed to a regression routine, and the α and β values saved to obtain 1,000 realizations of the replacement F (-α/β). ABC is the level of catch that accounts for scientific uncertainty in the estimate of the OFL and any other scientific uncertainty. The National Standard 1 guidelines prescribe that "the determination of ABC should be based, when possible, on the probability that an actual catch equal to the stock's ABC would not result in overfishing." ABC's for specification years 2018-2020 were updated for each stock of red and silver hakeThe southern silver hake ABC was adjusted by 4 percent to account for the average amount of offshore hake catches in southern silver hake trips.

Using proxy values for F_{MSY} approved by the 51st SAW (NEFSC 2011a) and estimates of scientific uncertainty for the reference point and for the three year moving average for NMFS trawl survey biomass, ABCs were updated for red and silver hake were updated by stock area per the current specification in Amendment 19. The small-mesh multispecies ABCs are expressed as a percentile of the overfishing level (OFL) distribution that estimates quantifiable scientific uncertainty. Described below are the existing ABC specifications for red and silver hake:

- Northern and southern red hake ABCs based on the 40th percentile of the stochastic estimate of OFL.
- Northern and southern silver hake ABCs based on the 25th percentile of the stochastic estimate of OFL. In the southern stock area, the ABC is increased by 4% to account for the customary estimated catches of offshore hake.

Estimated OFL for both red and silver hake are summarized in Table 47, Table 48, and Figure 30**,** Figure 31 based on the median value of the OFL distribution. The resulting OFL estimates for northern silver hake stock was 58,345 mt (90% Confidence interval of 12,732 – 313,558 mt) and 37,108 mt (90% Confidence interval of 12,340 – 336,384 mt) for the southern silver hake. Northern red hake OFL estimate was 807 mt (90% confidence interval of 192 - 1388 mt) and 1,122 mt (90% confidence interval of 745 – 1,520 mt) for the southern red hake stock.

The recommended 2018 – 2020 ABC for red and silver hake are also provided in Table 47Table 48 and Figure 30Figure 31**.**

Silver hake 2018 -2020 ABC set at 25th percentile to account for scientific uncertainty:

- 31,030 mt (53% of OFL; 908% of 2016catch) north
- 20,171 mt (54% of OFL; of 2016 catch) southern whiting

Red hake 2018 2020 ABC set at 40th percentile to account for scientific uncertainty:

- 720mt (89% of OFL; 178% of 2016 catch) north
- 1,060 mt (94% of OFL; 97% of 2016 catch) south

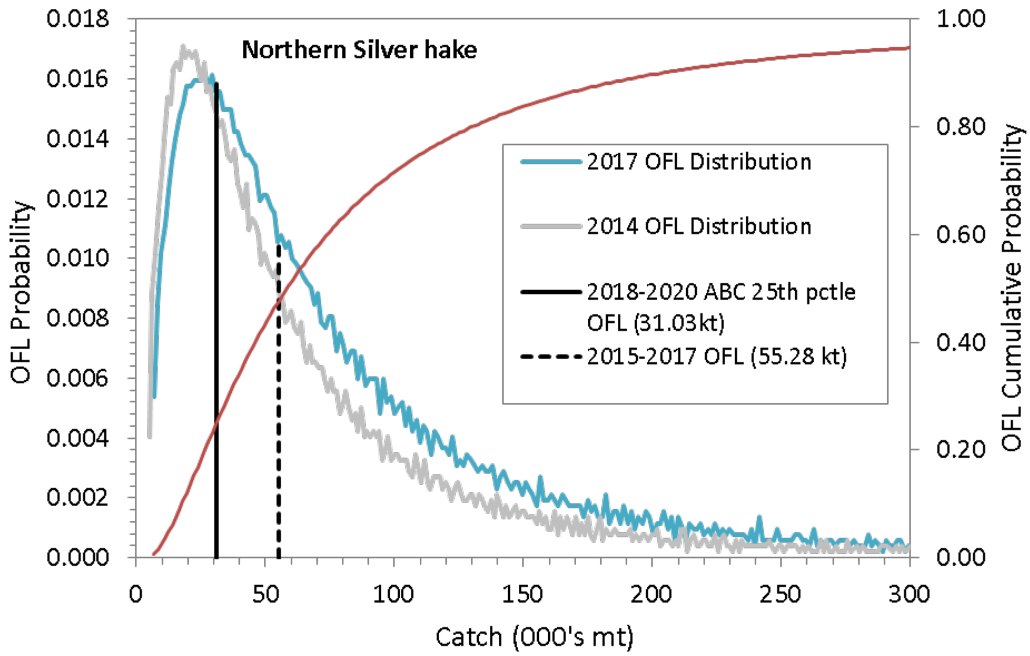
Table 36. Summary stock status and Overfishing limit (OFL) for specification year 2018-2020for both northern and southern silver hake stocks. Allowable Biological Catch (ABC) estimate, defined as the 25th percentile of OFL distribution and associated risk of exceeding FMSY proxy are provided.

	North	South
3-year Average Fall Index 2014-2016 (kg/tow)	19.92	1.05
BMSY Proxy Threshold (kg/tow)	3.21	0.83
Ratio of 3-year average Fall index (2014-2016) to BMSY Proxy	6.21	1.27
3-Year Average Relative Exploitation Index 2014-2016 (kt/kg)	0.15	5.85
FMSY Proxy 1973-1982 (kt/kg)	2.78	34.18
Ratio of 3-year average Exploitation index (2014-2016) to FMSY Proxy	0.05	0.17
OFL (000's mt) based on median of probability value from the OFL distribution	58.35	37.11
ABC (000's mt) = 25th Percentile of OFL distribution	31.03	20.17*
ACL (000's mt)	29.48	19.16
ACL/OFL	0.51	0.52
Pr (F > FMSY) @ ACL	0%	0%

Table 37. Summary stock status and Overfishing limit (OFL) for specification year 2018 – 2020 for both northern and southern red hake stocks. Allowable Biological Catch (ABC) estimate, defined as the 40th percentile of OFL distribution and associated risk of exceeding FMSY proxy are provided.

	North	**South**
3-year Average Spr. Index 2015-2017 (kg/tow)	5.13	0.38
BMSY Proxy Threshold (kg/tow)	1.27	**0.51**
Biomass Stock Status - Ratio of recent 3-year average Spr. index to BMSY Proxy	4.06	0.75
2016 Relative Exploitation Index (kt/kg)	0.09	4.03
FMSY Proxy 1982-2010 (kt/kg)	0.16	3.04
Overfishing Stock Ststus - ratio of 3-year average Exploitation index (2011-2013) to FMSY Proxy	0.55	**1.33**
OFL (000's mt) based on median of probability value from the OFL distribution	0.81	1.12
ABC (000's mt) = 40th Percentile of OFL distribution	0.72	1.06
ACL (000's mt) = 95% of ABC	0.68	1.01
ACL/OFL	0.85	0.90
Pr (F > FMSY) @ ACL	4%	23%

Figure 14. 2014 updated OFL frequency distribution for the northern (TOP) and southern (BOTTOM) stock of silver hake derived as a cross product of the fall survey and relative exploitation probability distributions. The fall survey probability distributions were derived from the most recent 3-yr mean and variance and assuming a normal error structure while distribution of relative exploitation was calculated as the average of the ratios of catch to the fall survey biomass from 1973-1982 with a lognormal error structure.



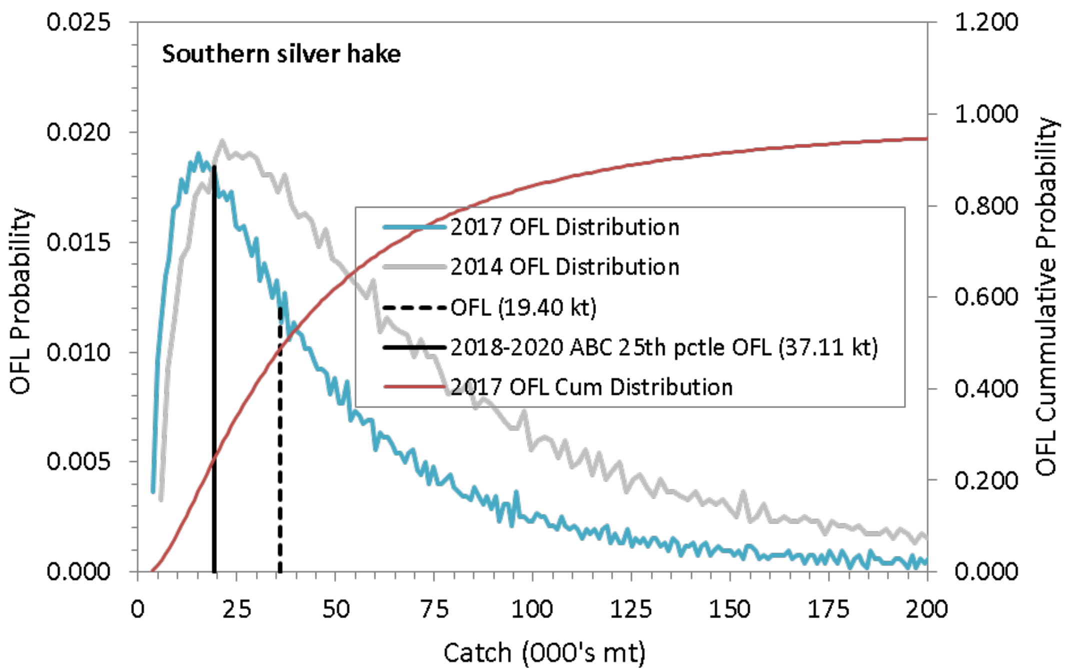
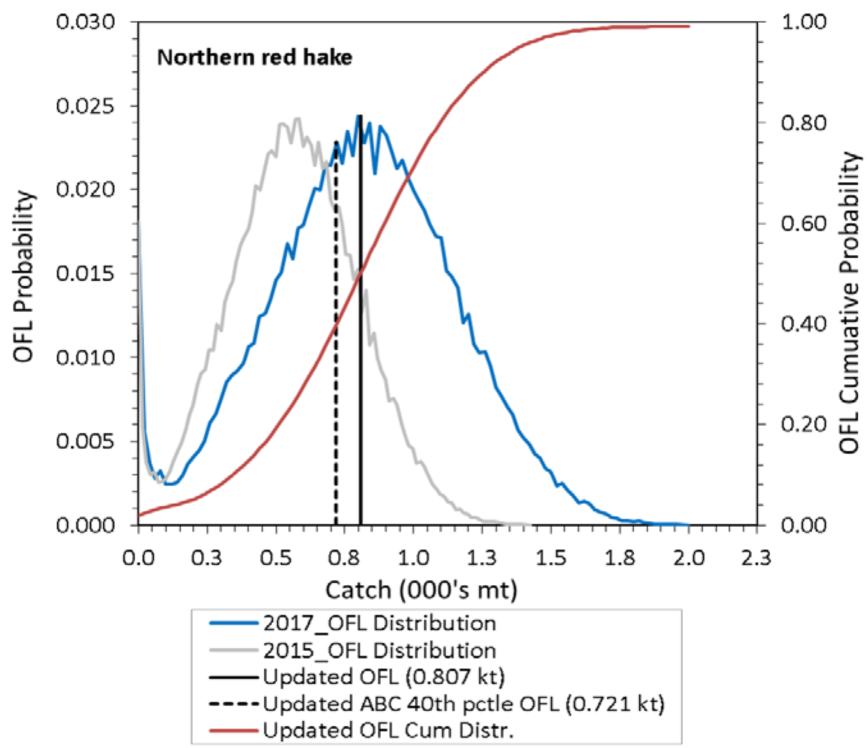
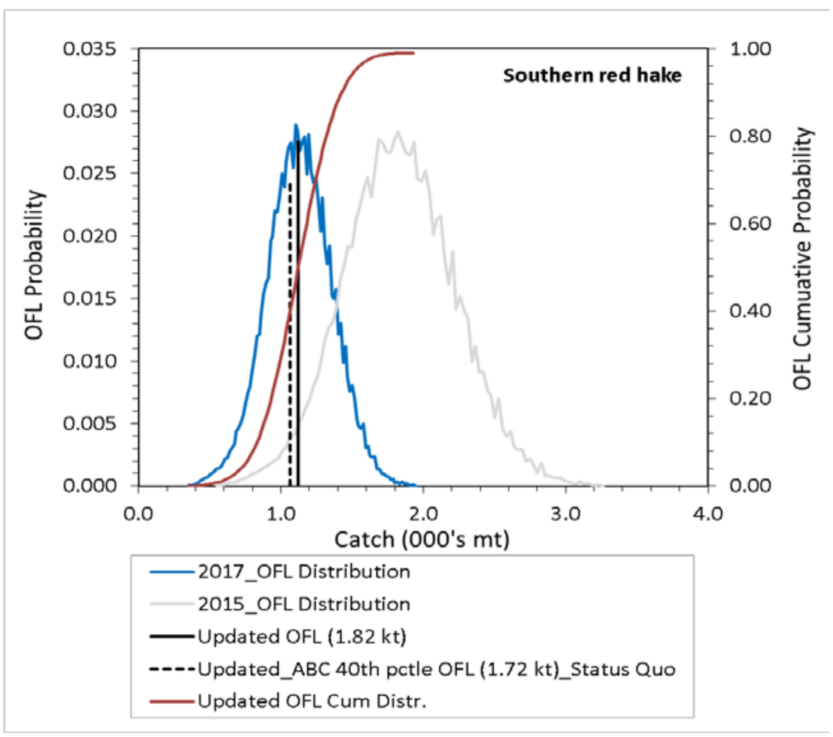


Figure 15. 2014 OFL frequency distribution for the northern (TOP) and southern (BOTTOM) stock of red hake derived as a cross product of the fall survey and relative exploitation probability distributions. The spring survey probability distributions were derived from the most recent 3-yr mean and variance and assuming a normal error structure while distribution of relative exploitation was calculated as the average of the ratios of catch to the spring survey biomass from 1982-2010 with a normal error structure.





8.3 *Risk Analyses (Probability of Overfishing)*

The probability of fishing mortality exceeding F_{MSY} proxy was estimated for a range of 2016 catches at the median of F_{MSY} for red and silver hake (Table 38-Table 41and Figure 15Figure 16). Relative exploitation was calculated at each realization of the survey biomass distribution (from the normal distribution as described above). The probability that a catch exceeded a percentile of F_{msy} was estimated as the sum of the products of the probability of each relative F exceeding that catch (1 or 0) and the probability of each survey realization.

Fishing at the proposed ABC's for both stocks of silver hake results in a 0% risk of exceeding the overfishing limit. However for red hake, there is a low risk (10%) and a moderate risk (23%) risk of exceeding the overfishing limit for the northern and southern stocks respectively at the proposed updated ABC levels.

Table 38. Risk of exceeding FMSY proxy over a range of catches (ABC and OFL estimate from the probability distribution in Bold) for **northern silver hake** stock. Relative F probabilities were calculated from realizations of the three average fall survey distribution and the OFL estimate. Note that the median OFL from the distribution as reported in table below is slightly different from the point estimate due to skewness in the distribution

Pctile of OFL	FY 2016-2017 Catch (kt)	% of OFL (58.35 kt)	% of 2016-2017 FY Catch	Prob. ($F > FMSY_{Proxy}$)
5	12.73	22%	372%	0%
10	17.67	30%	517%	0%
20	26.56	46%	777%	0%
25	**31.03**	**53%**	**908%**	**0%**
30	35.69	61%	1044%	0%
40	45.95	79%	1344%	0%
45	51.81	89%	1515%	17%
50	**58.35**	**100%**	**1707%**	**75%**
60	74.01	127%	2165%	97%
70	95.68	164%	2798%	97%
80	129.94	223%	3801%	97%

Table 39. Risk of exceeding FMSY proxy over a range of catches (ABC and OFL estimate from the distribution in Bold) for and **southern silver hake** stock. Relative F probabilities were calculated from realizations of the three average fall survey distribution and the OFL estimate. Note that the median OFL from the distribution as reported in table below is slightly different from the point estimate due to skewness in the distribution

Pctile of OFL distr.	FY 2016-2017 Catch (kt)	% of OFL (37.11 kt)	% of 2016 Catch	Prob. (F > $FMSY_{Proxy}$)
5	7.74	21%	201%	0%
10	10.84	29%	282%	0%
20	16.55	45%	431%	0%
25	**20.17**	**54%**	**525%**	**0%**
30	22.45	60%	584%	0%
40	29.14	79%	758%	7%
45	32.91	89%	856%	26%
50	**37.11**	**100%**	**966%**	**59%**
60	47.41	128%	1234%	97%
70	61.79	167%	1608%	97%
80	84.59	228%	2201%	97%

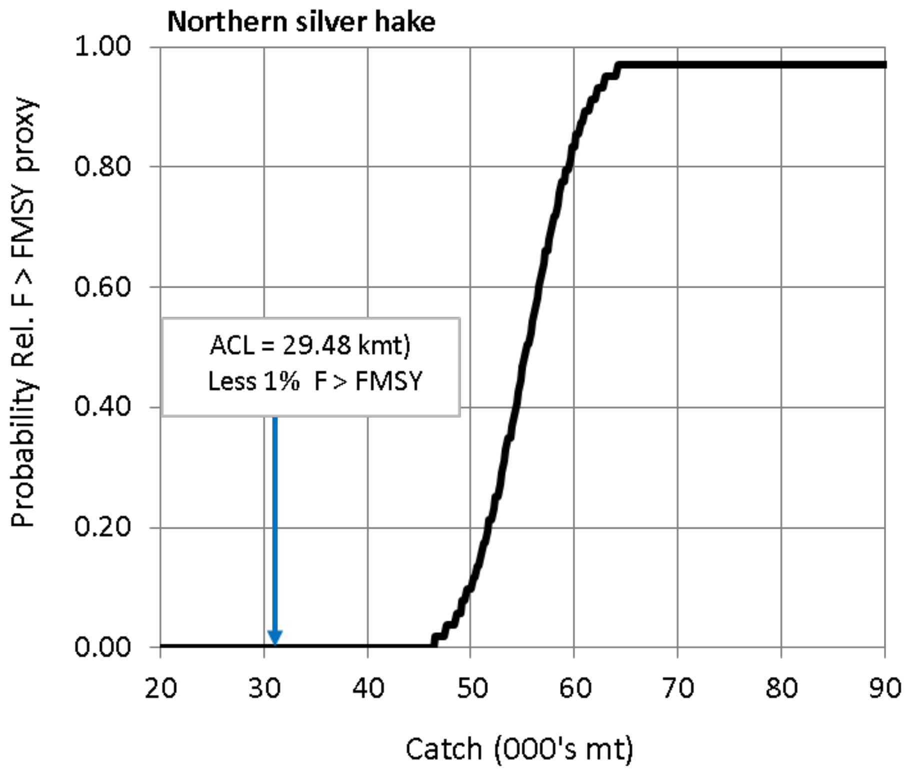
Table 40. Risk of exceeding FMSY proxy over a range of catches (ABC and OFL estimate from the probability distribution in Bold) for **northern red hake** stock. Relative F probabilities were calculated from realizations of the three average fall survey distribution and the OFL estimate. Note that the median OFL from the distribution as reported in table below is slightly different from the point estimate due to skewness in the distribution

Pctile of OFL	FY 2016-2017 Catch (kt)	% of OFL (0.807 kt)	% of 2016-2017 FY Catch	Prob. (F > $FMSY_{Proxy}$)
5	0.192	24%	47%	0%
10	0.343	42%	85%	0%
20	0.510	63%	126%	0%
25	0.571	71%	141%	0%
30	0.625	77%	154%	0%
40	**0.720**	**89%**	**178%**	**10%**
45	0.764	95%	189%	21%
50	**0.807**	**100%**	**199%**	**37%**
60	0.894	111%	221%	70%
70	0.988	122%	244%	93%
80	1.097	136%	271%	93%

Table 41. Risk of exceeding FMSY proxy over a range of catches (ABC and OFL estimate from the distribution in Bold) for and **southern red hake** stock. Relative F probabilities were calculated from realizations of the three average fall survey distribution and the OFL estimate. Note that the OFL from the distribution as reported in the table below is slightly different from the point estimate due to skewness in the distribution

Pctile of OFL distr.	FY 2016-2017 Catch (kt)	% of OFL (1.12 kt)	% of 2016 Catch	Prob. (F > $FMSY_{Proxy}$)
5	0.75	66%	68%	0%
10	0.83	74%	76%	0%
20	0.93	83%	86%	4%
25	0.97	86%	89%	8%
30	1.00	89%	92%	12%
40	**1.06**	**94%**	**97%**	**23%**
45	1.09	97%	100%	31%
50	**1.12**	**100%**	**103%**	**39%**
60	1.18	105%	108%	56%
70	1.24	111%	114%	72%
80	1.32	118%	121%	87%

Figure 16. Probability of exceeding FMSY proxy for the northern (TOP) and southern (BOTTOM) silver hake stocks based on the updated 2017 OFL. The risk of overfishing is a product of the probability of Rel.F > FMSY proxy for each survey realizations and the survey probability distributions.



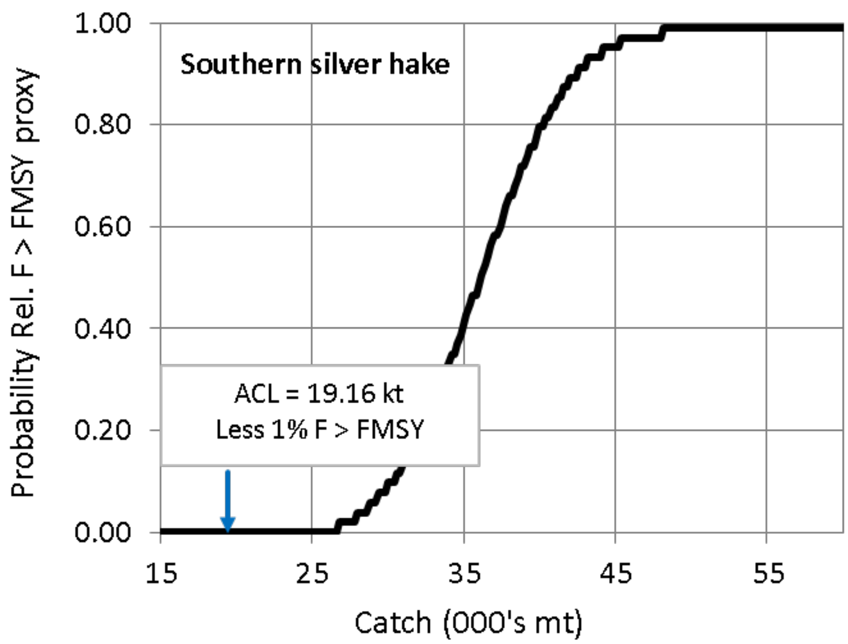
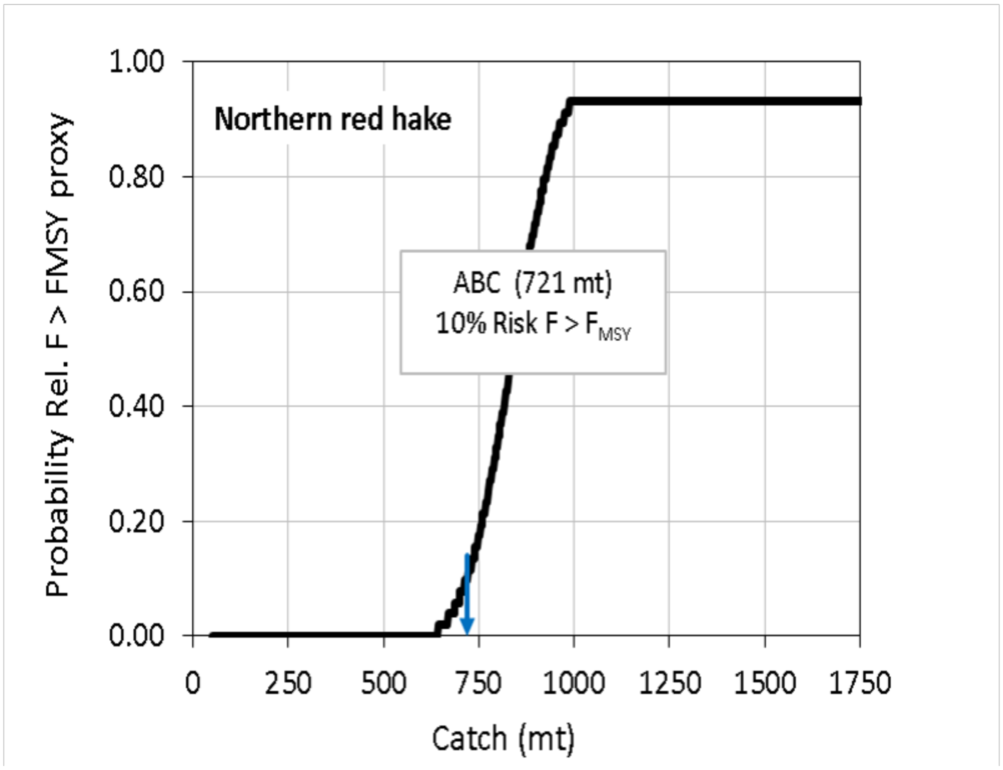
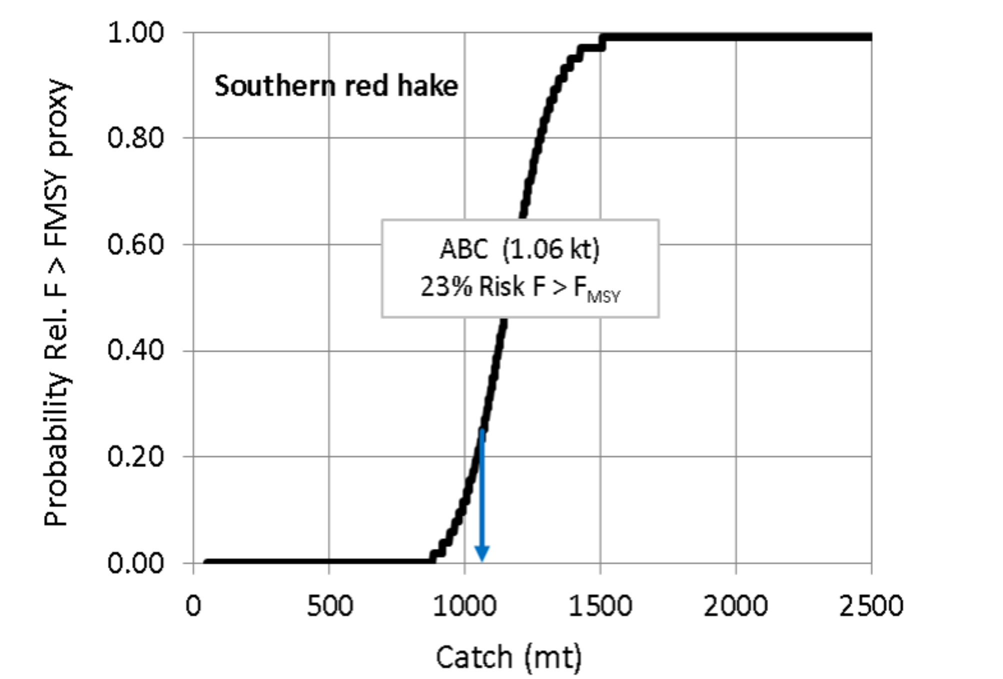


Figure 17. Probability of exceeding FMSY proxy for the northern (TOP) and southern (BOTTOM) red hake stocks based on the updated 2017 OFL. The risk of overfishing is a product of the probability of Rel.F > FMSY proxy for each survey realizations and the survey probability distributions.





8.4 Summary

This assessment updates fishery catch data through 2016 and survey indices through 2017 to develop ABC recommendations for fishing years 2018 – 2020 for both stocks of silver and red hake. Catch information consisted of commercial landings and discards, transfers-at-sea bait, discards and recreational catch information for red hake. Fishery catch data was combined with the Northeast Fisheries Science Center bottom trawl survey data from the fall for silver hake and the spring for red hake in an empirical Index-based approach that utilizes a three year moving average of the survey biomass index and the relative exploitation ratio of the total fishery catch to the survey index. Uncertainty in the Overfishing Limits was re-estimated to determine current ABC levels based on the existing definition in Amendment 19 (CITE).

Results of the assessment update show that both stocks of silver hake are not overfished and overfishing is not occurring. The three year average fall biomass index (19.92kg/tow in the north vs 1.05 kg/tow in the south) are both above the overfished management threshold (3.21 kg/tow in the north vs 1.27kg/tow in the south). In the north, the trend in the survey biomass index has continued to increase in recent years, supported by several recent strong year classes in the stock. On the contrary, the southern stock has been declining since 2011 with the exception of 2016 and is approaching the management threshold limit. Relative the silver hake in the north, recruitment has been weak in the recent three years, contributing to the decline in southern silver hake indices. The exploitation index measured as the ratio of catch to survey has remained consistently low (0.14 kt/kg in the north vs 3.86 kt/kg in the south) since the last update and well below the management thresholds for overfishing (2.78 kt/kg in the north vs 34.17 kt/kg in the south).

The red hake assessment update indicates the northern stock remains not overfished and overfishing is not occurring while in the south, the stock is considered overfished and overfishing is occurring. This represents a change in the biomass stock status for red hake in south from not overfished to now considered being overfished. Similar to silver hake, the northern red hake spring survey has been increasing in recent years and has been declining the south. The recent three year arithmetic mean biomass index based on the NEFSC spring bottom trawl survey for the northern stock (2015 -2017 = 5.13 kg/tow) is well above the management threshold of 1.27kg/tow. In the south, the three year arithmetic Spring biomass index (2015-2017 = 0.380 kg/tow) is only approximately 75% of the management threshold (0.51 kg/tow).

The northern red hake exploitation index has been declining owing to the steady increase in the spring survey biomass and relatively stable catches in recent years. The 2016 exploitation index for northern red hake was estimated at 0.09 kt/kg, and only 55% of the overfishing management threshold (0.163kg/kt). In the south, the 2016 exploitation was estimates at approximately 4.03kg/tow and is 33% above the overfishing management threshold (3.038 kt/kg).

The proposed 2018-2020 ABC recommendations for silver hake set at 25th percentile to account for scientific uncertainty was estimated at 31,030 mt in the north and 31,108 mt in the south. Both ABC's were approximately 50% of the OFL with negligible risk of exceeding the overfishing limit. Red hake proposed ABC recommendations for 2018-2020 set at 40th percentile of the OFL resulted in 807 mt in the north (89% of OFL) and 1,122 mt in the south (94% of OFL), with a (10%) and moderate (23%) risks of exceeding the overfishing limit in the north and the south respectively.

Stock status for the northern stock of silver hake continues to improve with increasing trends in population biomass and relatively stable catches in the recent years. While the southern stock of silver hake is considered to be above the biomass management threshold, the continued decline in the population biomass has fell below the biomass target and now approaching the threshold. The proposed OFL estimates suggest that both stocks of silver hake can withstand higher levels of catch with very little to no risk of exceeding the overfishing limit. However, should the survey biomass continue to decline in the future, the risk for exceeding the overfishing limit will be likely. Nevertheless, catch remains a major source of uncertainty in the overfishing reference points as implied in the OFL uncertainty estimates. The range of years (1973-1982) adopted in the previous 2010 benchmark assessments for deriving the overfishing definition reference points remain as a source of uncertainty because it does not incorporate contemporary measures of stock productivity. The transition from the 1970's to the 1980's highlight a period of high and low productivity with respect to the stock dynamics. Recognizing the potential for non-stationary productivity in the stock dynamics and the implications on estimates of the OFL, a precautionary basis for ABC should be maintained to account for the level of uncertainty in the OFL . Other sources of uncertainty in the assessment include: truncation in the age structure, estimates of predatory consumption, and catch estimates relative to mixed landings in the fishery (NEFSC, 2011).

Catches of red hake in the north continues to increase, dominated by discarding in the fishery due to very little market demand. The northern red hake population biomass has increased in recent years, largely supported by what appeared to be a 2014 strong year class. Since 2015, the survey has declined by 28% but stll above both the management target and threshold. The 2016 and 2017 survey estimates appears to be relatively stable with the 2017 estimate estimated at 4.66kg/tow, a 4% increase from 2016 survey value. The proposed ABC for 2014 suggest a 10% risk of exceeding the overfishing limit, should the population biomass and catches remaining at the current level.

In the south, red hake population biomass has been declining in the recent three years, with catches remaining relatively stable, but has also been dominated by discards in the fishery. The decline in the population biomass is accompanied by an increase in the relative exploitation index. Recruitment has been poor over the last two decades.

9.0 Whiting PDT Membership

The Whiting Plan Development Team includes:

1. Andrew Applegate, NEMFC
2. Larry Alade, NEFSC
3. Peter Burns, GARFO
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Also contributing to data in the report was John Sullivan, GARFO

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11.0 Appendix I – Assessment Background and Fishery Information

11.1 Introduction

This document summarizes the update of both the red and silver hake stock assessment results based on the last adopted benchmark approach in 2010 (NEFSC, 2011). Overfishing limits (OFL) and Allowable Biological Catch (ABC) were re-estimated based on the existing framework and specifications developed by the Northeast Fisheries Science Center (NEFSC) and the Council's Whiting Plan Development Team (PDT) are also provided in this document in response to the upcoming expiration of the existing whiting specification cycle (FY 2012-2014).

In the previous benchmark assessment, the goal was to produce an analytical model based assessment with appropriate reference point to set OFLs for red, silver and offshore hake. However, due to difficulties of the models resolving conflicting signals coming from low catches, particularly early in the time series and increasing stock biomass coupled with an increasing truncation in age structure, an index-based assessment for both red and silver hake were adopted as basis for reference points update and stock status determination. In the case of offshore, the SAW determined that there was no sufficient information about catch or trends in abundance and biomass to guide management of the stock. Instead, offshore hake are accounted for in the ABC estimates for the southern silver hake stock to account for customary reported catches of both species in the trawl fishery.

Due to the lack of an analytical model from the benchmark, the council directed the Whiting PDT in a collaborative effort with the NEFSC to develop ABC setting methods and recommend ABCs for the small mesh multispecies stocks that incorporates measures of scientific uncertainty. The methods were reviewed in April 2011 and did not become effective until May, 1 2012 via a Secretarial Amendment with an ACL specifications developed by the Council for Amendment 19.

In this updated assessment, catch and survey indices through 2014 updated to develop ABC recommendations for fishing year 2015-2017. Catch information consisted of commercial landings, discards for both red and silver hake and recreational catch data for only red hake. Catch data was combined with fisheries independent survey data from the fall and spring NEFSC trawl survey in a simple Index-based approach that utilizes a three year moving average of the fall and spring biomass index and relative exploitation ratio of catch to the survey. Uncertainty in the Overfishing Limits was re-estimated and ABC recommendations are provided based on the current Amendment 19 ABC definitions for both red and silver hake.

11.2 Life History

11.2.1 Silver hake

Silver hake (*Merluccius bilinearis)*, a nocturnal semi-pelagic predator also known as "whiting", are primarily distributed from Newfoundland to South Carolina. Silver hake are fast swimmers with sharp teeth, and are important fish predators that also feed heavily on crustaceans and squid **(Lock and Packer 2004**). In the U.S. waters, two stocks have been identified based on differences of head and fin lengths (**Almeida 1987**), otolith morphometrics **(Bolles and Begg 2000**), otolith growth differences, and seasonal distribution patterns (**Lock and Packer 2004**). The northern silver hake stock inhabits Gulf of Maine to Northern Georges Bank waters, and the southern silver hake stock inhabits Southern Georges Bank to the Middle Atlantic Bight waters (Figure 34).

While silver hake are considered a two stock population off New England, Bolles and Begg (2000) reported some mixing of silver hake due to their wide migratory patterns, but the degree of mixing among the management areas is unknown. A re-evaluation of stock structure in the 2010 benchmark silver hake assessment, based on trends in adult biomass, icthyolplankton survey, growth and maturity analyses, suggests that reproductive isolation between the two stocks is unlikely (NEFSC, 2011). Based on the mixed evidence on silver hake stock structure (morphometrics, tagging, discontinuous larva distribution, homogeneous growth and maturity), the 2010 benchmark concluded that there was no strong biological evidence to support either a separate or a single stock structure for silver hake. Thus, the two-stock structure definition remained as the basis for science and management (NEFSC, 2011).

Silver hake migrate in response to seasonal changes in water temperatures, moving toward shallow, warmer waters in the spring. They spawn in these shallow waters during late spring and early summer and then return to deeper waters in the autumn (**Brodziak et al. 2001**). The older, larger silver hake especially prefer deeper waters. During the summer, portions of both stocks can be found on Georges Bank, whereas during the winter, fish in the northern stock move to deep basins in the Gulf of Maine, while fish in the southern stock move to outer continental shelf and slope waters. Silver hake are widely distributed, and have been observed at temperature ranges of 2-17° C (36-63° F) and depth ranges of 11-500 m (36-1,640 ft). However, they are most commonly found between 7-10º C (45-50º F) (Lock and Parker 2004).

Female silver hake are serial spawners, producing and releasing up to three batches of eggs in a single spawning season (**Collette and Klein-MacPhee eds. 2002**). Major spawning areas include the coastal region of the Gulf of Maine from Cape Cod to Grand Manan Island, southern and southeastern Georges Bank, and the southern New England area south of Martha's Vineyard. Peak spawning occurs earlier in the south (May to June) than in the north (July to August). Over 50 percent of age-2 fish (20 to 30 cm, 8 to 12 in) and virtually all age-3 fish (25 to 35 cm, 10 to 14 in) are sexually mature (**O'Brien et al. 1993**). Silver hake grow to a maximum length of over 70 cm (28 in) and ages up to 14 years have been observed in U.S. waters, although few fish older than age 6 have been observed in recent years (**Brodziak et al. 2001, NEFSC 2011**).

Silver hake population constitutes an important link in the food web dynamics due to their high prey consumption capacity and as food source for major predators in the northwest Atlantic ecosystem. Consumptive estimates of silver hake indicate that predatory consumption represents a major source of silver hake.

11.2.2 Red hake

Red hake, *Urophycis chuss*, is a demersal gadoid species distributed from the Gulf of St. Lawrence to North Carolina, and are most abundant from the western Gulf of Maine through Southern New England waters. Red hake are separated into northern and southern stocks for management purposes. The northern stock is defined as the Gulf of Maine to Northern Georges Bank region, while the southern stock is defined as the Southern Georges Bank to Mid-Atlantic Bight region (Figure 34).

Red hake migrate seasonally, preferring temperatures between 5 and 12° C (41-54° F) (Grosslein and Azarovitz 1982). During the spring and summer months, red hake move into shallower waters to spawn, then move offshore to deep waters in the Gulf of Maine and the edge of the continental shelf along Southern New England and Georges Bank in the winter. Spawning occurs from May through November, with primary spawning grounds on the southwest part of Georges Bank and in the Southern New England area off Montauk Point, Long Island (Colton and Temple 1961).

Red hake do not grow as large as white hake, and normally reach a maximum size of 50 cm (20 in) and 2 kg (4.4 lb.) (Musick 1967). Females are generally larger than males of the same age, and reach a maximum length of 63 cm (25 in) and a weight of 3.6 kg (7.9 lb.) (Collette and Klein-MacPhee eds. 2002). Although they generally do not live longer than 8 years, red hake have been recorded up to 14 years old. In the northern stock, the age at 50 percent maturity is 1.4 years for males and 1.8 years for females, and the size at 50 percent maturity is 22 cm (8.7 in) for males and 27 cm (10.6 in) for females (O'Brien et al. 1993). In the southern red hake stock, the age at 50 percent maturity is 1.8 years for males and 1.7 years for females, and the size at 50 percent maturity is 24 cm (9.5 in) for males and 25 cm (9.8 in) for females (O'Brien et al. 1993).

Red hake prefer soft sand or muddy bottom, and feed primarily on crustaceans such as euphausiids, decapods, and rock crabs as well as fish such as haddock, silver hake, sea robins, sand lance, mackerel and small red hake (Bowman et al. 2000). Primary predators of red hake include spiny dogfish, cod, goosefish, and silver hake (Roundtree 1999). As juveniles, red hake seek shelter from predators in scallop beds, and are commonly found in the mantle cavities of (or underneath) sea scallops. In the fall, red hake likely leave the safety of the scallop beds due to their increasing size and to seek warmer temperatures in offshore waters (Steiner et al. 1982).

11.3 Fishery

The commercial silver hake fishery in the United States may have begun as early as the mid-1800s (Anderson et al, 1980). Prior to the early 1920s, landings of silver hake (commonly known as 'whiting') totaled less than seven million pounds annually, and most fishermen considered whiting a nuisance fish because its soft flesh tended to spoil quickly without refrigeration. Technological advances in handling, freezing, processing, and transportation aided in expanding this market as well as creating new opportunities to capitalize on whiting. Until this time, the fishery operated primarily inshore using pound nets. As the demand for whiting increased, operations began to extend offshore, and vessels started using otter trawls to catch more whiting. By 1950, U.S. commercial silver hake landings had increased to more than 45,000 metric tons. Floating traps, gillnets, purse seines, and longline trawls were also employed.

Today, almost all of the U.S. commercial silver hake catch is taken with otter trawls. Prior to 1960, the commercial exploitation of silver hake in the Northwest Atlantic was exclusively by U.S. fleets. Distant water fleets had already reached the banks of the Scotian Shelf by the late 1950s, and by 1961, scouting/research vessels from the former USSR were fishing on Georges Bank. By 1962, factory freezer fleets (ranging from 500 to 1,000 GRT) intensively exploited the whiting and red hake stocks on the Scotian Shelf and on Georges Bank. Led by the former USSR, the distant water fleet landed an increasingly larger share of silver hake catch from the Gulf of Maine, Georges Bank, and northern Mid-Atlantic waters. In 1962, the distant water fleet landed 41,900 tons of silver hake (43% of the total silver hake landings), but that number had increased to 299,200 tons (85% of the total silver hake landings) in 1965. That year marked the year of the highest total commercial silver hake landings, 351,000 tons. Unable to sustain such high rates of fishing, the abundance of silver hake off the U.S. Atlantic coast began to decline. As a result, total commercial catches decreased significantly after 1965 and reached a 20-year low of 55,000 tons in 1970. U.S. recreational landings also dropped after 1965 to about half the levels of previous years (Table 55 and Figure 35).

After 1970, catches of silver hake by the distant water fleet in U.S. waters increased again, especially in southern New England and the Mid-Atlantic. Between 1971 and 1977, distant water fleet landings from the southern stock averaged 75,000 tons annually and accounted for 90% of the total harvest from the southern stock. The size and efficiency of distant water fleet factory ships also increased, many ranging between 1,000 and 3,000 GRT. In 1973, the International Commission for the Northwest Atlantic

Fisheries established temporal and spatial restrictions that reduced the distant water fleet to small "windows" of opportunity to fish for U.S. silver hake. These windows restricted the distant water fleet to the continental slope of Georges Bank and the Mid-Atlantic. As effort control regulations increased, foreign fleets gradually left most areas of Georges Bank.

Although foreign fishing had ceased on Georges Bank by about 1980 and in the Mid-Atlantic by about 1986, the U.S. groundfish fleet's technologies and fishing practices began to advance, and between 1976 and 1986, fishing effort (number of days) increased by nearly 100% in the Gulf of Maine, 57% on Georges Bank, and 82% in southern New England (Anthony, 1990). Such increases in effort, although directed primarily towards principal groundfish species (cod, haddock, yellowtail flounder), were accompanied by a 72% decline in silver hake biomass. In turn, U.S. East Coast landings of silver hake began to decline, dropping to 16,100 tons in 1981. Since that time, landings have remained relatively stable, but at much lower levels in comparison to earlier years. U.S. East Coast silver hake catches are taken almost exclusively by otter trawls, either as bycatch from other fisheries or through directed fisheries targeting a variety of sizes of silver hake.

11.3.1 Commercial Landings

Commercial landings for both stocks (north and south) of red and silver hake were updated for years 2011-2013, derived from the trip-based allocation procedure described in the GARM III Data meeting (GARM 2007; Legault et al. 2008b; Palmer 2008; Wigley et al. 2007a). With the implementation of mandatory vessel trip reports (VTRs) since 1994, the port interview process was discontinued and the area and effort information was obtained directly from the VTRs. Unfortunately, the matching of dealer reports and VTRs has been problematic and secondary allocation procedures are needed to assign the area and effort information to dealer landings. Currently, a standardized procedure is used to assign area and effort from VTRs to dealer-reported landings from 1994 onward (Wigley et al.2007a). The product from this process is stored the NEFSC allocation (AA) database tables. Landings are matched to VTRs in a hierarchal manner, with landings matched at the top tier (level A, direct matching) having a higher confidence in the area and fishing effort attribution than those matched at the lower tiers. The matching rates have improved over time with over 78% of silver hake and 80% of red hake landings being matched at the highest level since 2011.

For Southern mixed landings of whiting (i.e. silver and offshore hake), a survey length-based species split by proportion model was used to disaggregate total commercial landings of silver hake from offshore. Offshore hake and silver hake survey proportions at length were updated for years 2011-2013 and were applied to the nominal commercial landings at length of whiting. Estimated proportions of landed offshore hake have not varied since the last benchmark assessment in 2010 with offshore hake only constituting approximately 1% of total whiting landings. Time series average proportion of landed offshore hake since 1955 is approximately 4% and has not varied from the current basis for adjusting southern silver hake ABC to account for offshore hake (Figure 36).

Updated landings of silver hake for years 2011-2013 show that landings of silver hake in the northern stock have increased by approximately 32% since the 2010 benchmark assessment from 1,004 mt in 2009 to 1,370 mt in 2013 while in the south, silver hake landings decreased by 29% from 6,750 mt in 2009 to 4,790 mt in 2013**(**Table 55 and Figure 35) . Conversely, landings of red hake increased in the north by 12% from 85mt in 2009 to 95mt in 2013 and decreased in the south by 24% from 575mt in 2009 to 439 mt in 2013 (Table 56 and Figure 37). The commercial fishery for both red and silver hake continues to be dominated by vessels fishing with trawl gear with less than 10% contributed from other fleets (Table 57Table 60**;** Figure 38 Figure 39)

11.3.2 Commercial Discards

Silver hake and red hake are discarded in the commercial fishery primarily due to limited market demand. Other reasons include poor quality, minimum retention size (too small) and filled quota, particularly for northern red hake stock.

Direct sampling of the commercial fishery for discards has been conducted by fisheries observers since 1989. Beginning in May 2010, Amendment 16 created a new class of fisheries observers to support sector management of the northeast US groundfish fishery. These new observers were termed ‘at-sea monitors’, or ASMs. ASMs are deployed in the same manner as observers certified through the Northeast Fisheries Observer Program (NEFOP; Palmer et al. 2013), but they collect only basic information on fishery catches and length frequency distributions. Between 2010 and 2012, ASM coverage averaged approximately 20% of total groundfish trips whereas regular observer coverage (NEFOP) averaged about 6% (Palmer et al. 2013). An evaluation of length frequency distributions showed very minor differences between NEFOP and ASM when the sampling was sufficient to make comparisons. For the purpose of this assessment update, no distinctions were made between data collected by ASM and NEFOP observers with respect to discard estimation.

Total silver hake and red hake discards for years 2011-2013 was estimated using the same approach from the previous benchmark assessment. The discard estimation approach is based on the Standardized Bycatch Reporting Methodology (SBRM) recommended in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). This method estimates observed ratio of species x to kept all species for large mesh (≥ 5”) otter trawl, small mesh (< 5”) otter trawl, shrimp trawl, scallop dredge, Sink gillnet and longline and applied to total landings by these gears and by half year. Uncertainty in the discard estimates was estimated based on the SBRM approach detailed in the GARM III Data meeting (GARM 2007, Wigley et al. 2007b). Average annual discards of the total catch for both northern silver and red hake in the recent three years (2011-2013) were approximately 11% and 59% respectively (Table 55Table 56). In the south, the recent three years average annual discards was approximately 17% for silver hake and 53% red hake (Table 55Table 56). Total discards of silver hake in the north increased by 30% from 190 mt in 2009 to 250 mt in 2013 while in the south, total discards decreased by 24% from 840 mt in 2009 to 640 mt in 2013 (Table 55). Similarly, total discards of red hake increased in the north but by more than double from 100 mt in 2009 to approximately 220 mt in 2013 while in the south discards decreased by 33% from 870 mt in 2009 to 580 mt in 2013 (Table 56).

Evaluation of discard estimates by selected major gear groups (i.e. large mesh and small mesh trawl) all show increased discarding of red and silver hake in the north with the exception of the small mesh trawl. In 2009, northern silver hake discards was dominated by the small mesh and currently by the large mesh trawl and shrimp trawlers. For northern red hake, the small mesh trawl remains to be the primary source of red hake discarding. In the south, discards of red and silver hake by the both the large and small mesh trawl fleets decreased since 2009 with the small mesh trawl being the dominant gear (Table 62Table 65 and Figure 40 and Figure 41).

11.3.3 Recreational Catch

In the previous benchmark assessment, recreational catch estimates were based on data collected under the Marine Recreational Fisheries Statistical Survey (MRFSS) which began in 1981. In this assessment update, MRFSS data have been re-estimated using the revised methodologies consistent with the new Marine Recreational Information Program (MRIP) which has replaced MRFSS program (**NMFS 2012**). Following the consensus from the previous benchmark assessment, recreations catches for silver hake was not included in this update due to the low amounts taken from recreational component. Hence, it is expected that recreational catches of silver hake will have negligible impact on total catch. Recreational catches of red hake are presented in Table 61and Figure 42. Recreational catches of red hake have been variable without trend. Since 2009, recreational catches of red hake in the north has doubled from 1.2 mt to 2.4 mt in 2013. However, in the south red hake recreational catches declined by 30% from 108 mt in 2009 to 76 mt in 2013.

11.4 Survey Indices

Research bottom trawl surveys are conducted annually by the Northeast Fisheries Science Center (NEFSC) in April (denoted as spring) and October (denoted as fall) extending from the Gulf of Maine to Cape Hatteras in offshore waters at depths 27-365 meters dating back to 1963. The NEFSC survey is conducted using a randomized stratified design which allocates samples relative to the size of the strata, defined by depth.

The NEFSC spring and fall strata catches (strata 20-30 and 36-40 in the north and 1-19 and 61-76 in the south) were used to estimate relative stock biomass and relative abundance for both red and silver hake (Figure 43). Conversion coefficients, which adjust for survey door, vessel, and net changes in NMFS groundfish surveys (red hake uses 1.31 for BMV oval doors and silver hake uses 2.360 for the Yankee 41 net; Rago et al. 1994; Byrne and Forrester 1991) were applied to the catch of each tow for years 1973-2008.

Beginning in 2009, the NMFS bottom trawl surveys were conducted with a new vessel, the NOAA ship *Henry B. Bigelow*, which uses a different net and protocols from the previous survey vessel. Conversion coefficients by length have been estimated for both red and silver hake (**NEFSC, 2011**) and were applied in this assessment.

It should be noted that the NEFSC spring 2014 survey did not cover the full range of the southern stock due to mechanical difficulties experienced by NOAA research vessel Henry B. Bigelow. As a result, the PDT recommends that the assessment update for red hake in the south should be based on years 2011-2013 while the northern stock is based on years 2012-2014.

Northern silver hake fall biomass indices has increased substantially since 2009, peaking to the second highest value observed over the entire time series in 2012 (20.43 kg/tow) and declining by approximately 18% in 2013 to 16.75 kg/tow (147% increase relative to 2009). In the south, silver hake fall survey biomass index has been slightly more variable with an increasing trend as well. Since 2009, the index peaked to the fourth highest value (2.82 kg/tow) observed over the entire time series in 2010 and has shown a steady decline ever since and currently estimated at 1.33 kg/tow (a 22% increase since 2009; Table 66Table 67**;** Figure 44). The age composition for silver hake in the fall survey continues to be dominated by age 1 and 2 with very little to no indication of expansion in the age structure in the north and south stocks. Since 2009, both stocks have shown a strong age-1 recruitment signals but barely showing up in subsequent age groups likely due to cannibalism and predation effects on the smaller size group fish (Figure 46**)**.

The red hake spring biomass index in the north has shown a decreasing trend since 2010 (2.80 kg/tow), declining by approximately 52% in 2013 (1.35 kg/tow). In 2014, the spring biomass index increased to 3.02 kg/tow, an 8% increase above 2010 survey estimate. Similarly, the southern red hake spring biomass index has also declined after a brief increase in 2011. The 2013 terminal year estimate used in this assessment update (note 2014 is treated as a missing value) declined by approximately 32% from 0.94 kg/tow in 2010 to 0.64 kg/tow in 2013 (Table 68Table 69**;** Figure 45). Average fish size for red hake survey catches shows a general downward trend since the mid-1980s in both the northern and southern stocks. Note in the north that average catch for smaller size fish increased in 2014. However, it will be premature to make any inferences about the strength of this size class until subsequent observations are collected from additional surveys (Figure 47**).**