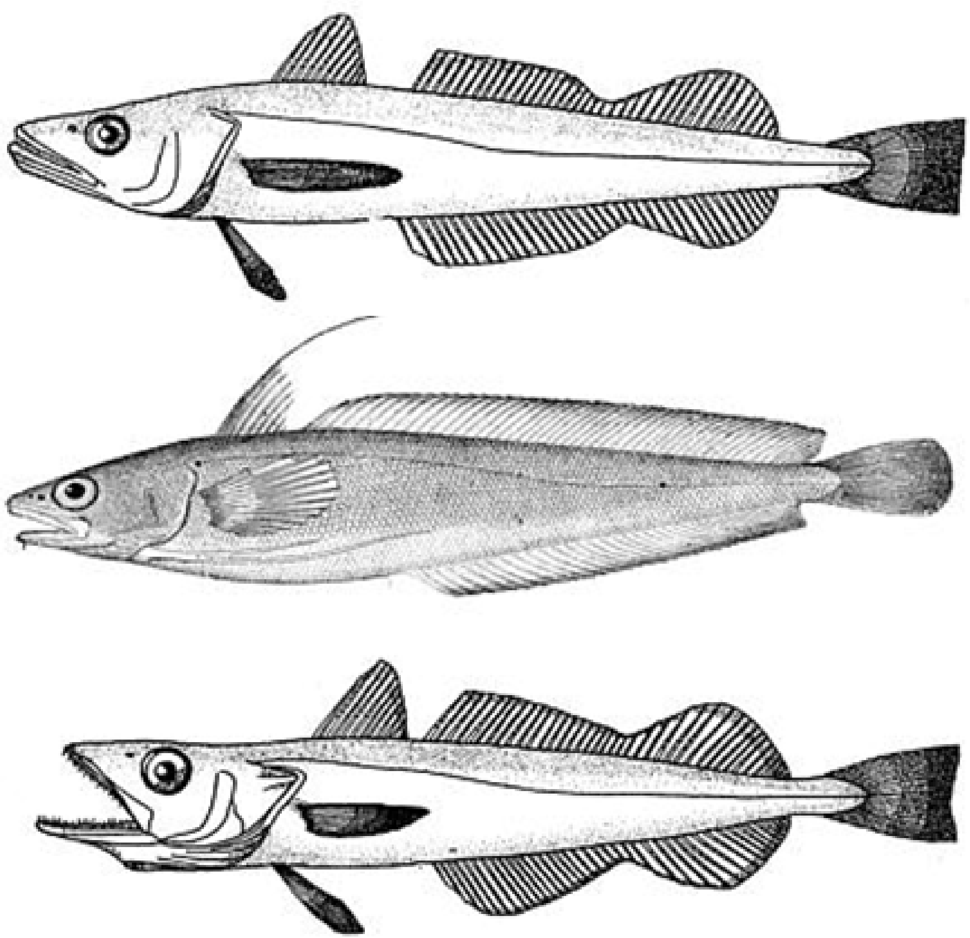
NEW ENGLAND FISHERY MANAGEMENT COUNCIL

Stock Assessment and Fishery Evaluation (SAFE) Report for Fishing Year 2013

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 2015-2017 fishing years. The PDT set the ABC for both silver hake stocks using the 25th percentile and both red hake stocks using the 40th percentile. The OFL for northern and southern silver hake are set at 43,608 mt and 60,148 mt, respectively. The OFL for northern and southern red hake are set at 331 mt and 3,534 mt, respectively. The PDT assessed the performance of the fishery and analyzed and identified current fishery trends. The number of vessels participating in the whiting fishery has steadily increased while vessels landing small mesh multispecies has decreased. All small-mesh multispecies catches decreased from 2012 to 2013. The trends differ from red hake and silver hake, with red hake discards making up a much larger percentage of catch than silver hake. Overall landings have decreased slightly from 2010-2013. The stock assessment update shows that both stocks of silver hake are not overfished and overfishing is not occurring. Both stocks of red hake are not overfished, however overfishing is occurring in the northern stock and not occurring in the southern stock. This is a change from the previous assessment, where no overfishing was occurring in the northern red hake stock.

An update assessment was performed by the Northeast Fisheries Science Center (NEFSC) and presented to the Whiting PDT. 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) were presented to the Scientific and Statistical Committee (SSC) on August 26, 2014. 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 this process, 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.

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 2015-2017 are shown in the table below.

Table 1. Proposed 2015-2017 specifications

Stock	OFL (mt)	ABC (mt)	ACL (mt)	Change from 2012-2014
Northern silver hake	43,608	24,383	23,161	+85%
Northern red hake	331	287	273	+2.6%
Southern silver hake	60,148	31,180	29,621	-8.2%
Southern red hake	3,400	3,179	3,021	-2.4%

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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 2015-2017 fishing years. Specifications will be reviewed by the Council at the September 2014 meeting and approved as final at the November 2014 meeting, with the intention of becoming effective on May 1, 2015.

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 2013. Survey biomass indices were updated through fall 2013 for northern and southern silver hake[1], spring 2014 for northern red hake[2], and spring 2013 for southern red hake[3]. 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.

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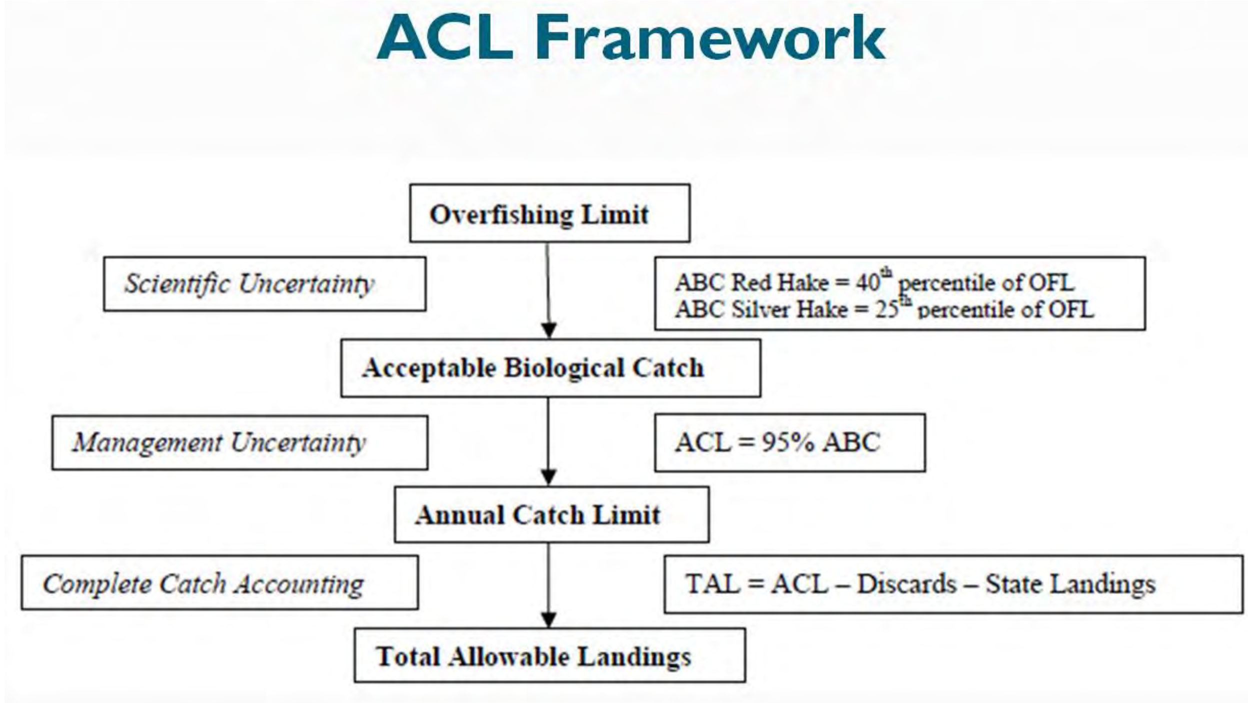
[1] The silver hake assessment is reliant on the fall survey and for setting ABCs because the benchmark assessment deemed it to be the most representative of trends in stock biomass.
[2] The red hake assessment is reliant on the spring survey and for setting ABCs because the benchmark assessment deemed it to be the most representative of trends in stock biomass. The spring 2014 survey data are final and audited.
[3] The spring survey in 2014 could not be used in the southern stock management area because a substantial fraction of strata were unsampled because of mechanical problems with the vessel.

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



Northern silver hake: the assessment update estimates OFL at 43,608 mt. Using the 25th percentile of scientific uncertainty estimates, the ABC would be 24,383 mt and is estimated to have a near zero probability of overfishing. This ABC is an 85% increase over the 2012-2014 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 (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 s approach for ABC specification.

Scientific uncertainty percentile	Catch (thousand mt)	Percent of OFL point estimate	Percent of 2013 catch	Probability of overfishing ($F > FMSY_{Proxy}$)
5	9.96	22%	576%	0%
10	13.83	30%	799%	0%
20	20.85	45%	1205%	0%
25	**24.38**	**53%**	**1409%**	**0%**
30	28.05	61%	1621%	0%
40	36.19	79%	2092%	4%
45	40.79	89%	2358%	25%
50	**45.87**	**100%**	**2652%**	**68%**

Southern silver hake:, the update assessment estimates OFL at 60,148 mt. Using the 25th percentile of scientific uncertainty estimates, the ABC would be 32,424 mt and is estimated to have a near zero probability of overfishing. This ABC is a 2% decrease compared to the 2012-2014 specification. The 31,177 mt ABC estimate in the update assessment was increased by 4% to account for average catch proportions of offshore hake, according to the thorough analysis of species composition in the benchmark assessment and regulations adopted in Amendment 19.

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 (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	Catch (thousand mt)	Percent of OFL point estimate	Percent of 2013 catch	Probability of overfishing (F > $FMSY_{Proxy}$)
5	12.34	21%	215%	0%
10	17.39	29%	302%	0%
20	26.55	44%	462%	0%
25	**31.18**	**52%**	**542%**	**0%**
30	36.05	60%	627%	0%
40	46.81	78%	814%	4%
45	52.97	89%	921%	27%
50	59.69	100%	1038%	56%

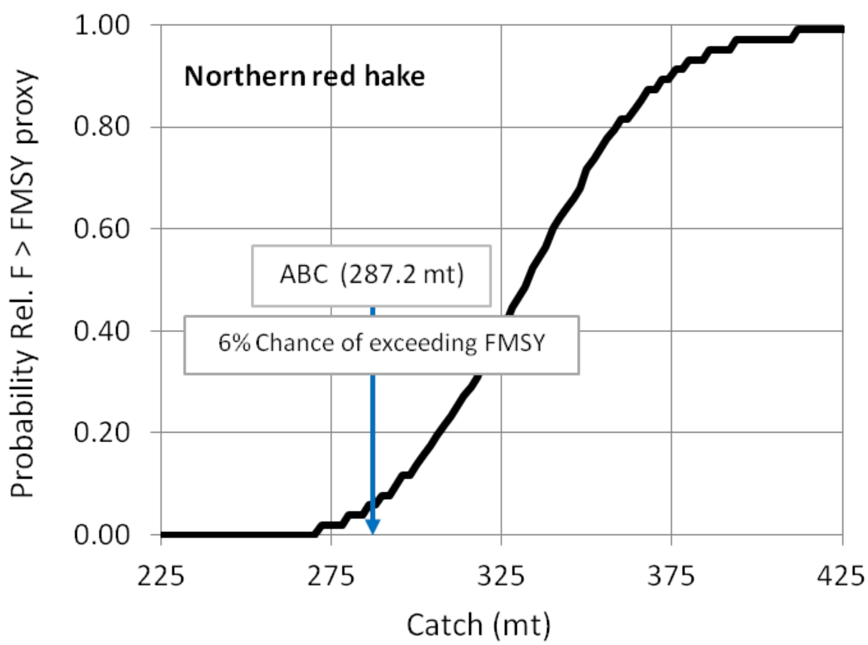
Northern red hake: the assessment update estimates OFL at 331 mt. Using the 40th percentile of scientific uncertainty estimates, the ABC would be 287 mt and is estimated to have a near zero probability of overfishing. This ABC is a 3% increase compared to the 2012-2014 specification. Due to the relatively precise estimate of scientific uncertainty (see Figure 2), there may be room for increasing the ABC relative to the OFL using a higher value on the cumulative frequency distribution of scientific uncertainty. On one hand, a higher catch limit may not significantly increase risk of continuing overfishing. On the other hand, a higher catch limit on the cumulative uncertainty distribution may not substantially increase the ABC value either (Table 4). One concern that should be considered is that a substantial fraction (> 10%Percent) of the 2014 survey biomass consisted of an incoming year class (fish less than 21 cm).

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 adopte approach for ABC specification.

Scientific uncertainty percentile	Catch (thousand mt)	Percent of OFL point estimate	Percent of 2013 catch	Probability of overfishing (F > $FMSY_{Proxy}$)
5	0.077	24%	21%	0%
10	0.137	43%	38%	0%
20	0.204	63%	56%	0%
25	0.228	71%	63%	0%
30	0.250	78%	69%	0%
35	0.269	84%	74%	0%
40	**0.287**	**89%**	**79%**	**6%**
45	0.305	95%	84%	17%
50	**0.322**	**100%**	**88%**	**37%**

Figure 2 - Risk of exceeding F_{MSY} for northern red hake.



For southern red hake, the assessment update estimates OFL at 3,534 mt. Using the 40th percentile of scientific uncertainty estimates, the ABC would be 3,179 mt and is estimated to have a 29 percent

(Figure 3) probability of overfishing. This ABC is an 8% decrease compared to the 2012-2014 specification.

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 (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	Catch (thousand mt)	Percent of OFL point estimate	Percent of 2013 catch	Probability of overfishing (F > $FMSY_{Proxy}$)
5	2.08	61%	189%	0%
10	2.34	69%	213%	0%
20	2.68	79%	244%	10%
25	2.82	83%	257%	14%
30	2.95	87%	268%	17%
35	3.07	90%	279%	23%
40	**3.18**	**93%**	**289%**	**29%**
45	3.29	97%	299%	35%
50	**3.40**	**100%**	**309%**	**41%**

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

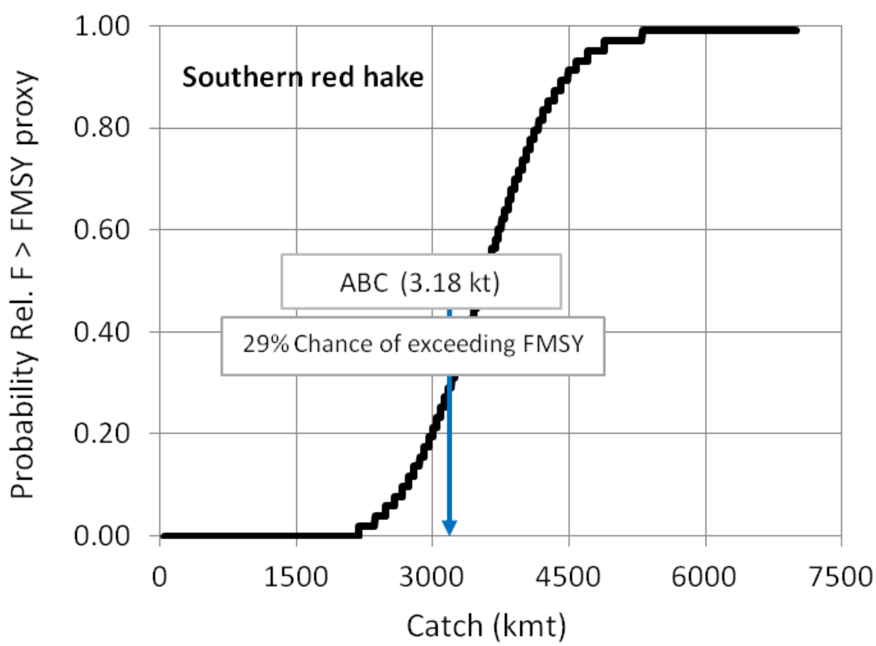


Table 6 - Summary of 2015-2017 ABC specification and OFL estimates for small mesh multispecies, not adjusted for catches of offshore hake. OFL are based on the point estimate and not the median from the OFL probability distribution.

	OFL (mt)	ABC (mt)	P(>OFL)	Change in ABC compared to 2012-2014
Northern silver hake	43,608	24,383 @ 25th percentile	< 1%	85% increase
Southern Whiting	60,148	31,177 @ 25th percentile	< 1%	2% decrease
Northern red hake	331	287 @ 40th percentile	6%	3% increase
Southern red hake	3,534	3,179@ 40th percentile	29%	8% decrease

3.2 Scientific and Statistical Committee Specification Approval

To: Tom Nies, Executive Director
From: Scientific and Statistical
Committee Date: September 15, 2014
Subject: Whiting (silver hake) and red hake overfishing levels (OFLs) and acceptable biological catch (ABC) recommendations for fishing years 2015 – 2017

The SSC met on August 26, 2014 in Boston, Massachusetts, to address the following term of reference (TOR):

Review the recent assessment updates and the work of the Whiting Plan Development Team (PDT) and provide an OFL and an ABC for each year for northern silver hake, southern silver hake, northern red hake and southern red hake for fishing years 2015-2017 that will meet management objectives and prevent overfishing.

To meet this TOR, the SSC considered the following documents:

3.1 2013 Small-Mesh Multispecies SAFE Report (Draft August 2014)
3.2 Presentations by Whiting Plan Development Team members Andrew Applegate and Dr. Larry
Alade
3.3 Acceptable Biological Catch Recommendations for Whiting for Fishing Years 2012 – 2014 (Sep
13, 2011 Memo from SSC to Tom Nies)

The SSC recommends OFLs for each of the four hake stocks as estimated during the operational assessment and ABCs using the current control rule, estimated by the NEFSC and reviewed by the Whiting PDT. These specifications would remain the same in 2015, 2016 and 2017 in the absence of new information suggesting a change is warranted. The values are as follows (all in metric tons, mt):

Stock	Fishing year 2015-2017	
	OFL	Annual ABC
Northern silver hake	43,608	24,383
Southern silver hake	60,148	31,180
Northern red hake	331	287
Southern red hake	3,400	3,179

In developing this catch advice, the SSC considered the reasons for overfishing of the northern stock of red hake. The fishing year catch exceeded the ABC (by 38% in 2012 and by 29% 2013)[4] and the OFL (by 23% in 2012 and 15% in 2013), and the relative F in 2013 exceeded the F_{MSY} proxy (by 6%), but the three-year (2012-2014) stock biomass index did not decline, influenced mostly by the higher 2014 biomass estimate and new recruitment first observed in spring 2014. Therefore, overfishing was primarily a result of exceeding catch limits rather than scientific uncertainty that led to substantial misspecification of catch advice. The most appropriate response is to more effectively control catch, including improved estimation of discards, rather than revise the risk tolerance (i.e., percentile of OFL for ABC). Concerns about the overfishing definition lead the SSC to recommend that the biological reference points should be updated at the next appropriate opportunity and more thoroughly re-evaluated at a benchmark assessment.

In particular, movements of fish in response to variations in environmental conditions have the potential to alter both survey indices and landings. Several published studies have identified associations between red and silver hake distributions and temperature, with the relationships being particularly strong for silver hake. Given that the reference points for these stocks rely on survey indices, temperature-dependent movements or changes in catchability have the potential to alter the perception of the stock. For example, the Gulf of Maine has warmed rapidly since 2004, and this increase in temperature mirrors the increase in northern silver hake. If the increase in the survey index is driven by increased catchability rather than an increase in abundance, there is an increased risk of overfishing (and, conversely, foregone yield during cold periods). Fish responses to climate change may also alter distributions and induce changes in productivity, which may influence our perception of assessment stock boundaries. Future assessments for these stocks should evaluate whether temperature or other environmental indicators (e.g. the Gulf Stream North Wall Index) can explain variability in the survey indices as well as changes in stock structure, and if so, should consider how to incorporate this knowledge when setting benchmarks.

[4] New information reviewed by the Whiting PDT after the SSC meeting indicates that the 2012-2014 OFL was underestimated by 53 mt and the 2012-2014 ABC was underestimated by 39 mt. Taking these corrections into account, the fishing year catch exceeded the ABC (by 21% in 2012 and by 13% 2013) and the OFL (by 5% in 2012) The fishing year catch was under the corrected OFL by 2% in 2013.

The SSC noted that selection of the 25th percentile for setting the silver hake ABC was chosen by the Council for other considerations besides climate change, is more risk-averse than the 40th percentile used for red hake and might serve as an additional buffer against uncertainty due to climate change, but should be more explicitly evaluated.

Finally, the SSC appreciated the PDT's preparation of an integrated SAFE report, combining the assessment results, OFL and ABC calculations, socio-economic information in the form of a Fishery Performance Report chapter, and other useful information. The inclusion of the Fishery Performance Report was especially welcome as it addresses a recommendation made by the SSC in order to better utilize our social science expertise. Currently, the social scientists on the SSC are meeting as a sub-group to identify priority metrics and recommendations for incorporating those metrics into development of catch advice. The PDT's SAFE report will serve as a useful model of the continuing work of the social science sub-group.

<u>Summary of recommendations</u>

1. OFLs and ABCs should remain unchanged for each stock in 2015, 2016 and 2017 in the absence of new information suggesting otherwise. Values for each are provided in the table above.

2. Overfishing of the northern stock of red hake was due to exceeding catch limits, rather than misspecification of catch advice due to scientific uncertainty. Therefore, efforts are needed to better control catch, including improved estimation of discards.

3. Reference points should be updated at the next appropriate opportunity and more thoroughly re-evaluated at a benchmark assessment.

4. Effects of changing temperatures on the behavior of both red and silver hake, and therefore their availability to the survey and fishery, should be thoroughly investigated given the implications for assessment outcomes, catch advice and catch.

5. Inclusion of a Fishery Performance Report in the integrated SAFE report was a welcome addition. The SSC's social science sub-group is developing recommendations for how to utilize information included in the development of catch advice.

4.0 Advisory Panel Discussion

The Whiting Advisory Panel reviewed the Fishery Performance Report (Section 6.0) and the update assessment results (Section 8.0), adding the following observations and comments:

- Compared to fishing year 2012, catch declined in fishing year 2013 from a variety of factors including:
    - One of the major participants in the fishery was conducting a major vessel overhaul which made few trips targeting whiting during the year.
    - Much of the catch decline in southern whiting was attributable to a reduction in discards. More vessels that catch squid and whiting on Georges Bank began using a 'rope' trawl when targeting squid. Unlike squid, whiting tend to charge the approaching very large mesh in the 'rope' section of the trawl and escape capture.

- Whiting bycatch attributed to trips using shrimp trawls in the southern area are probably due to some CT and RI vessels targeting royal red shrimp in deep water.

- Historically, red hake catches in the Gulf of Maine were much higher when there were no groundfish closed areas and before the small-mesh exemption areas restricted fishing. This change may have implications for setting the OFL based on 1982 to 2012 conditions.

- Advisors and fishermen believe that red and silver hake are moving northward in response to warming water temperatures and that existing stock boundaries may no longer be appropriate for setting catch limits.

- The various net types on 2008 to 2012 observed trips could be classified into four general categories to estimate red hake and groundfish catch rates as follows:
    - Raised footrope trawls, 2-seam and 4-seam (required in five exemption areas and sometimes used in the Cultivator Shoals Area)
    - Standard groundfish trawls (including 'Box' trawls), 2-seam and 4-seam
    - Shrimp trawls
    - Flynets and balloon trawls

- It is important to address overages with management measures that preserve the existing small-mesh exemption areas and seasons

- Developing limited access qualifications for targeting whiting with small-mesh trawls in both the northern and southern fishery management areas is important because:
    - New entrants into the small-mesh fishery would make it more difficult for the fishery to not exceed sub-ACLs
    - Large amounts of landings that are concentrated over short periods of time can depress prices and would have negative economic effects.
    - New entrants in the small-mesh multispecies fishery are likely to lack experience to avoid bycatch and fish cleanly.

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[5] 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[6]. 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.

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

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[5] 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."

[6] 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."

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.

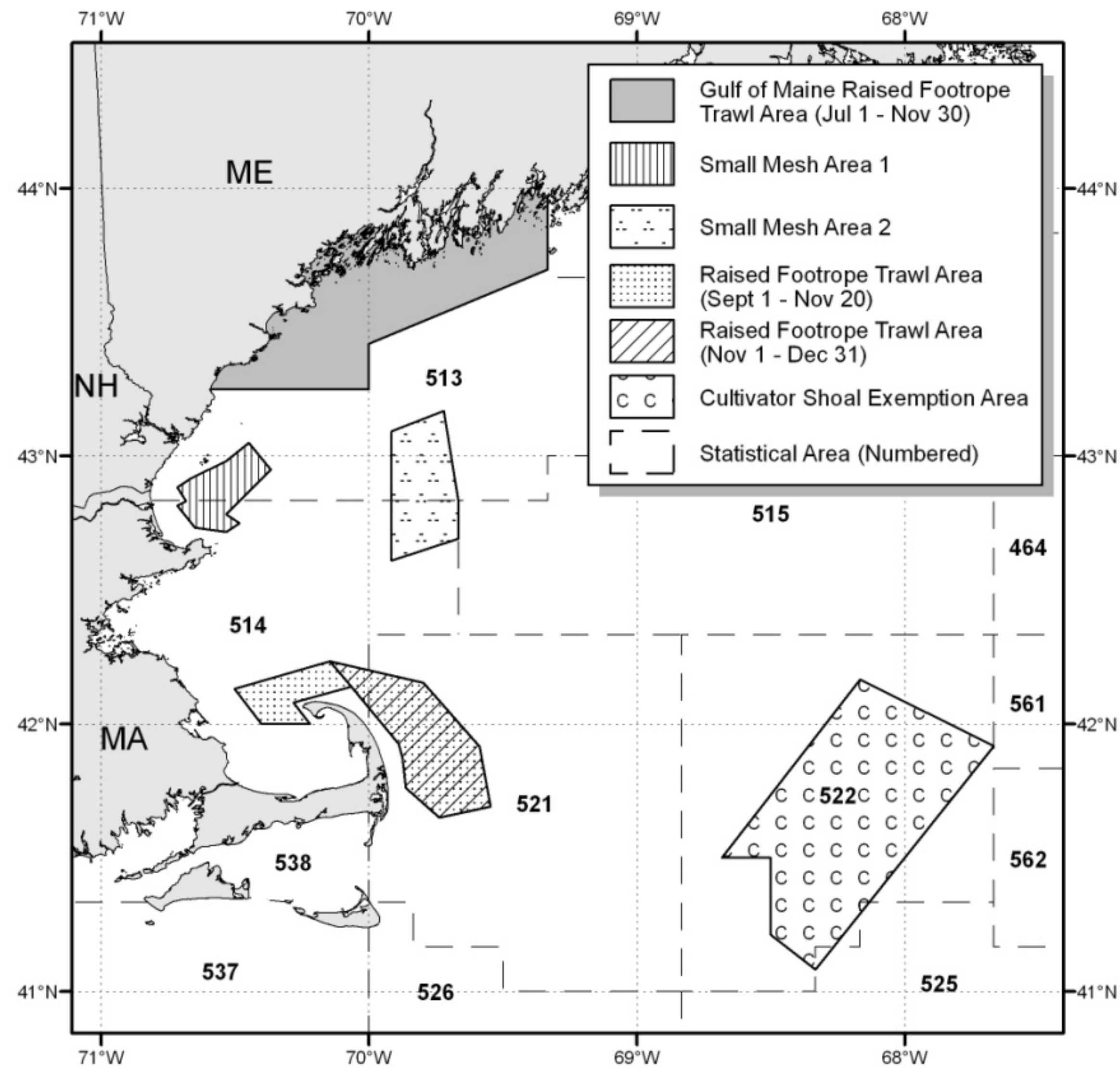
A **Secretarial Amendment** (2012) brought this portion of the FMP into compliance with the Magnuson-Stevens Act requirements to have (1) annual catch limits and (2) measures to ensure accountability for each Council managed fishery. A Secretarial Amendment was necessary because the development of Amendment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

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.

Figure 4 - 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. 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 2012-2014 specifications.

	Northern Red Hake	Northern Silver Hake	Southern Red Hake	Southern Whiting
Overfishing Limit (OFL)	314 mt	24,840 mt	3,448 mt	62,301 mt
Acceptable Biological Catch (ABC)	280 mt	13,177 mt	3,259 mt	33,940 mt*
Annual Catch Limit (ACL)	266 mt	12,518 mt	3,096 mt	32,295 mt
Discard Estimate (2008-2010)	65% (173 mt)	26% (3,255 mt)	56% (1,718 mt)	13% (4,198 mt)
State-Waters Landings (3%)	2.8 mt	278 mt	42 mt	842 mt
Federal TAL (mt)	90.3 mt	8,985 mt	1,336 mt	27,255 mt
Federal TAL (lb)	199,077.4 lb	19,809,243 lb	2,945,376 lb	60,086,990 lb

* Includes an increase of 4 percent to account for offshore hake catch.

Northern red hake is the only stock that has exceeded its annual catch limit since the implementation of these specifications. All small-mesh multispecies catches decreased from 2012 to 2013. Southern red hake catch decreased by a small amount, from 37 percent to 35.5 percent. Northern silver hake catch was almost 18 percent of the catch limit in 2012, but less than 14 percent in 2013. Likewise, southern whiting dropped slightly from 20 percent to 18 percent, and even northern red hake catch dropped from 145 percent of the annual catch limit to 136 percent.

Compared to the 2008-2010 discard estimate used in the specifications setting, the 2012-2013 average northern red hake discards have increased, from 65 to 70 percent. The discard estimates have decreased compared to the previous average for southern red hake (56 down to 49 percent) and northern silver hake (26 down to 14 percent). Meanwhile, the discards have remained at 13 percent for southern whiting. Landings by vessels only permitted to fish in state waters averaged 3 percent.

While combined, small-mesh multispecies landings make up 77 percent of the total catch, the trends are very different for red hake versus silver hake/whiting. Red hake discards are a very significant source of catch (ranging from 46 percent to 73 percent); whereas, silver hake/whiting discards are a much smaller portion of the catch (averaging 14 percent.)

Beginning in fishing year 2014, the northern red hake possession limit trigger was reduced to 45 percent of landings. This reduces the possession limit from 5,000 lb to 400 lb for the remainder of the fishing year, effective August 5, 2014. However, because such a large portion of the total catch is discards, and a significant portion of those discards occurring before the possession limit was reduced in fishing year 2012, a lower possession limit reduction trigger may not help constrain the fishery within its annual catch limit moving forward.

Table 10 - Fishing year 2012 red hake landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (266 mt)	Percent of Total Catch
Northern red hake commercial landings	229,771	104	39.2%	27%
Northern red hake research landings	0	0	0%	0%
Northern red hake state-permitted only vessel landings	275	0	0%	0%
Northern red hake estimated discard	621,592	282	106.0%	73%
Northern red hake recreational catch (MRIP)	718	0.3	n/a	0%
Northern red hake catch*	851,638	386	145.2%	100%
Southern red hake landings	1,280,755	581	18.8%	50%
Southern red hake research landings	7,562	3	0.1%	0%
Southern red hake state-permitted only vessel landings	88,211	40	1.3%	3%
Southern red hake estimated discard	1,163,991	528	17.1%	46%
Southern red hake recreational catch (MRIP)	85,779	39	n/a	3%
Southern red hake catch*	2,540,519	1,152	37.2%	100%

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

Table 11 - Fishing year 2012 whiting landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (12,518 mt)	Percent of Total Catch
Northern silver hake commercial landings	4,200,989	1,906	15.2%	87%
Northern silver hake research landings	1	0	0.0%	0%
Northern silver hake state-permitted only vessel landings	31,547	14	0.1%	1%
Northern silver hake estimated discard	615,554	279	2.2%	13%
Northern silver hake recreational landings (MRIP)	15,774	7	n/a	0%
Northern silver hake catch*	4,848,091	2,199	17.6%	100%
Southern whiting landings	11,113,309	5,041	15.6%	78%
Southern whiting research landings	39,257	18	0.1%	0%
Southern whiting state-permitted only vessel landings	911,212	413	1.3%	6%
Southern whiting estimated discard	2,256,994	1,024	3.2%	16%
Southern whiting recreational landings (MRIP)	0	0	n/a	0%
Southern whiting catch*	14,320,773	6,496	20.1%	100%

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

Table 12 - Fishing year 2013 red hake landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (266 mt)	Percent of Total Catch
Northern red hake commercial landings	253,309	115	43.2%	31.8%
Northern red hake state-permitted only vessel landings	-	-	0%	0%
Northern red hake estimated discard	543,388	246	92.7%	68.2%
Northern red hake recreational catch (MRIP)	5,477	2.5	n/a	n/a
Northern red hake catch*	796,697	361	135.9%	100.0%
Southern red hake landings	1,079,335	490	15.8%	44.6%
Southern red hake state-permitted only vessel landings	4,644	2	0.1%	0.2%
Southern red hake estimated discard	1,338,764	607	19.6%	55.3%
Southern red hake recreational catch (MRIP)	163,837	74	n/a	n/a
Southern red hake catch*	2,422,743	1,099	35.5%	100.0%

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

Table 13 - Fishing year 2013 whiting landings and discards by stock area.

	Pounds	Metric tons	Percent of ACL (12,518 mt)	Percent of Total Catch
Northern silver hake commercial landings	3,160,615	1,434	11.5%	82.7%
Northern silver hake state-permitted only vessel landings	63,863	29	0.2%	2%
Northern silver hake estimated discard	599,370	272	2.2%	15.7%
Northern silver hake recreational landings (MRIP)	99,099	45	n/a	n/a
Northern silver hake catch*	3,823,848	1,734	13.9%	100.0%
Southern whiting landings	11,264,810	5,110	15.8%	88.9%
Southern whiting state-permitted only vessel landings	30,927	14	0.0%	0.2%
Southern whiting estimated discard	1,371,754	622	1.9%	10.8%
Southern whiting recreational landings (MRIP)	650	0	n/a	n/a
Southern whiting catch*	12,667,491	5,746	17.8%	100.0%

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

6.2 Permit Information

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). The number of vessels landing small mesh multispecies has steadily decreased from 1996, when 736 vessels reported landings, to a low of 336 vessels in 2005. A moderate increase in the number of participating vessels has occurred since 2005, with 381 vessels reporting small mesh landings in 2013, the last year for which data are available. (Figure 5) Section 3.4 describes the geographical changes of where the participants are landing fish.

A similar trend can be seen in the number of dealers reporting buying small-mesh multispecies has remained relatively stable, ranging from a high of 140 dealers in 1996, to a low of 78 in 2005, and back up to 92 in 2013. In addition, as described in the following section, where the participating dealers are located has changed.

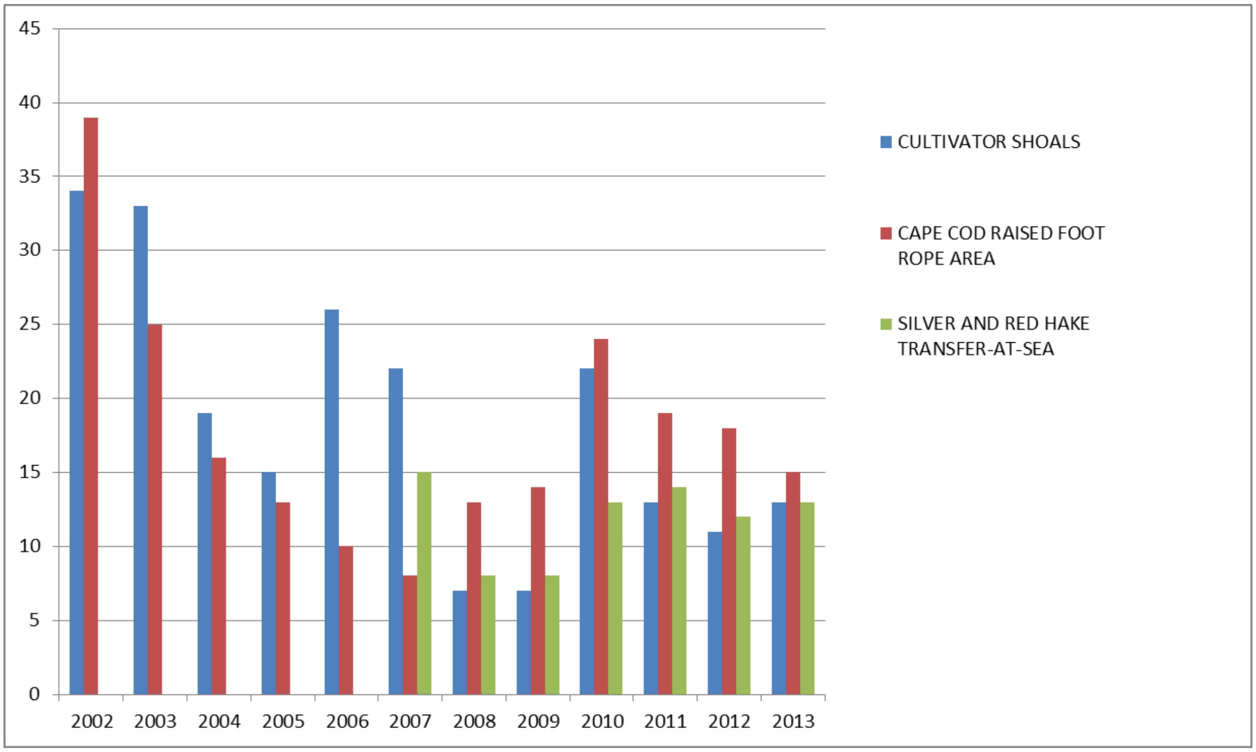
Table 14 - Number of northeast multispecies Category K permits, and the number of vessels landing small-mesh multispecies.

Fishing Year	Number Of Northeast Multispecies Category K Permits Issued	Number Of Vessels Landing Small-Mesh Multispecies, All Permit Categories
1996	150	736
1997	441	710
1998	546	731
1999	640	736
2000	736	703
2001	773	651
2002	848	561
2003	866	511
2004	964	391
2005	1,080	336
2006	1,054	351
2007	1,039	399
2008	1,022	406
2009	972	436
2010	934	369
2011	831	388
2012	824	389
2013	802	381

Figure 5 - Number of federally permitted vessels and dealers reporting small-mesh multispecies by calendar year. ***Note change in scale for number of dealers.***

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

Figure 7 illustrates the value of small-mesh multispecies by states with a major interest in this fishery over time. There are small-mesh landings in other states in any given year, however, most of them cannot be displayed because of confidentiality reasons. As such, this report displays the revenue over time of just the top five states with involvement in the small mesh fishery.

Figure 8 shows the same information by port of landing for the top five ports with reported small-mesh multispecies landings. For the most part, these ports have maintained consistent participation, with the exception of a sharp decrease for Point Judith, Rhode Island, and a less steep increase for Gloucester, Massachusetts.

Figure 7 - Trends in small mesh revenues by state of landing

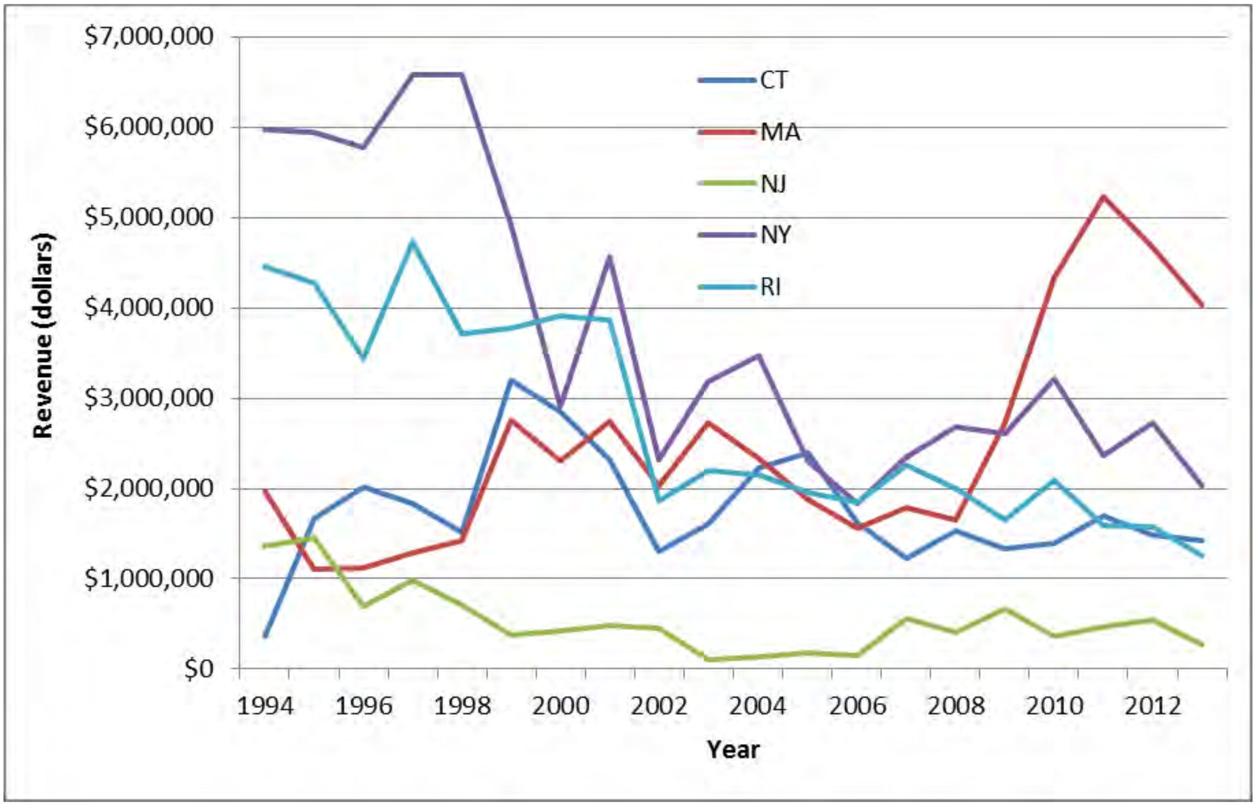
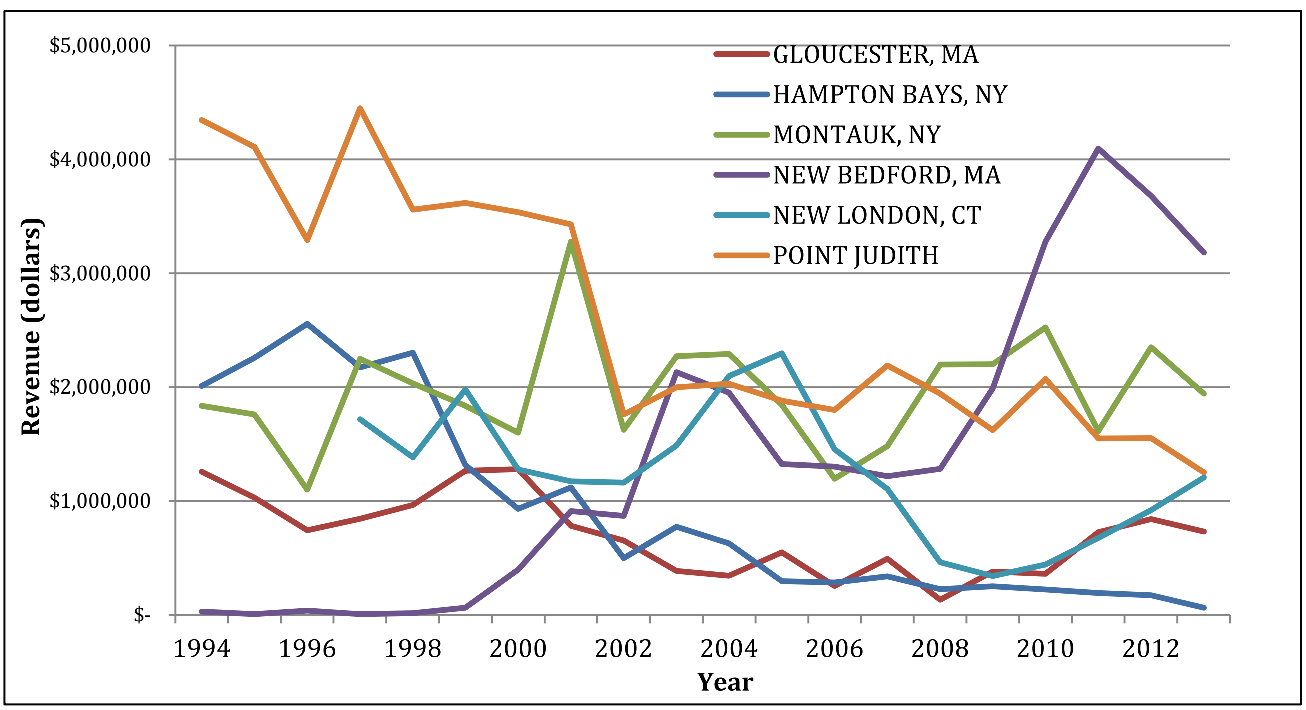


Figure 8 - Trends in small-mesh revenue by port of landing



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. Because of confidentiality reasons, some of the dependence categories have been combined. 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. Figure 9 shows the proportion of total annual dealer-reported revenue derived from small-mesh multispecies of vessels that had at least one dealer-reported small-mesh multispecies targeted trip in a calendar year (a small-mesh multispecies targeted trip is defined as a trip with 50% or more of revenue derived from small-mesh multispecies). On average, from 1994-2013, 73 percent of vessels, with at least one reported small-mesh multispecies targeted trip, generate less than 20 percent of their overall revenue from this fishery. Of those, 56 percent of vessels generate less than 10 percent of their revenue from the small-mesh multispecies fishery. On average, only 7 percent of vessels generate 50 percent or more of their revenue from the small-mesh multispecies fishery. (Table 15) There are so few vessels in any given year that are highly dependent on revenue from this fishery, that they cannot be displayed by 10 percent categories, due to confidentiality reasons.

Likewise, there are very few, if any, dealers who heavily depend on the revenue generated by small-mesh multispecies. The percentage of dealers whose reported revenue from small-mesh multispecies between 0 and 10 percent averaged 78 percent over the time period (Table 16). Again, the percent dependence categories needed to be collapsed to protect confidentiality. As seen with the previous information, there is a peak around 1997, a low between 2005 and 2006, a steady increase to 2010, and a decline from 2010 to 2013. (Figure 9 and Figure 10)

Figure 9 - Total number of vessels, by percent dependence on small-mesh multispecies

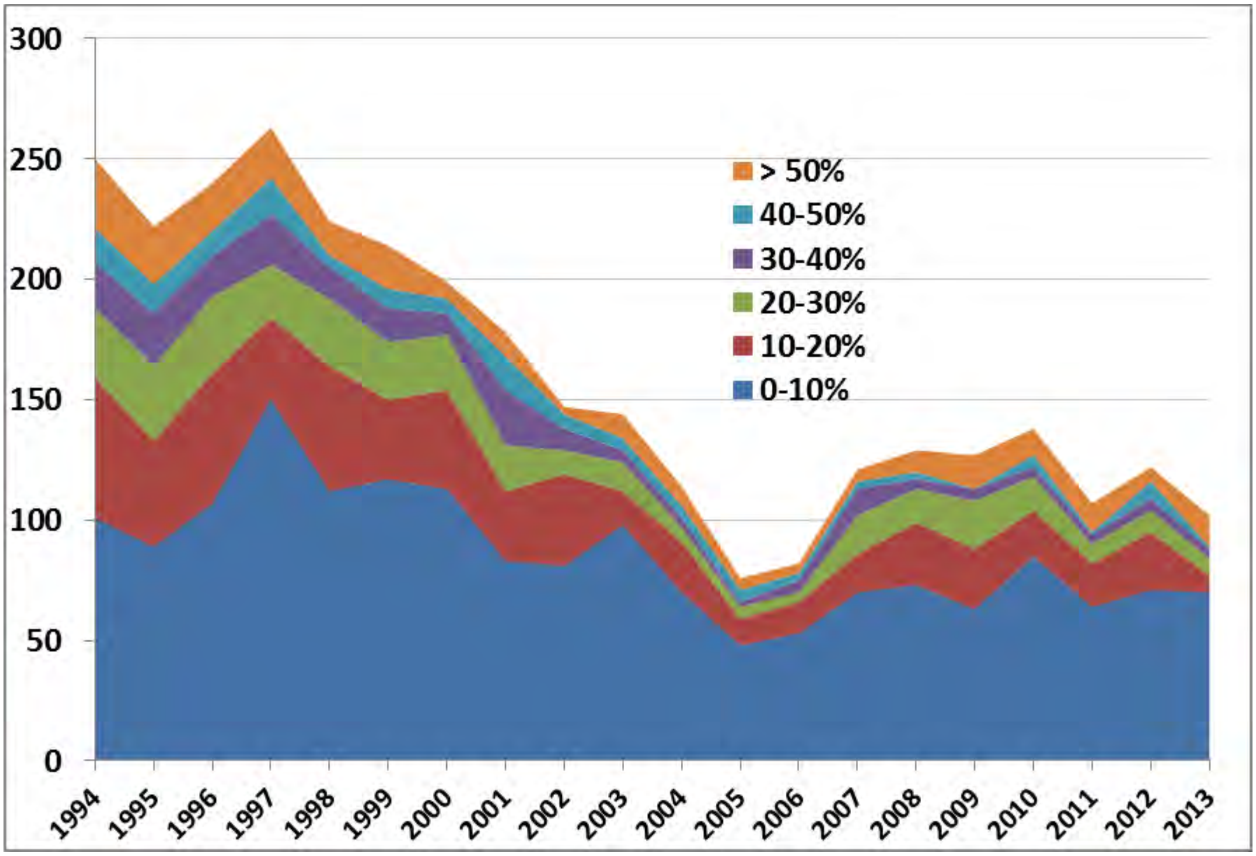


Table 15 - Annual proportion of vessels by percent dependence category

Calendar year	0-10%	10-20%	20-30%	30-40%	40-50%	> 50%
1994	40%	23%	12%	8%	6%	12%
1995	40%	20%	14%	10%	5%	11%
1996	45%	23%	13%	7%	4%	8%
1997	57%	13%	8%	8%	6%	8%
1998	50%	23%	13%	6%	2%	6%
1999	55%	15%	11%	7%	4%	8%
2000	57%	21%	12%	5%	3%	4%
2001	47%	16%	11%	13%	8%	6%
2002	55%	26%	7%	6%	4%	2%
2003	68%	10%	8%	3%	3%	7%
2004	61%	18%	5%	4%	4%	7%
2005	63%	14%	7%	3%	7%	7%
2006	65%	16%	5%	6%	4%	5%
2007	58%	13%	13%	9%	2%	4%
2008	57%	20%	11%	3%	2%	7%
2009	50%	20%	16%	4%	0%	11%
2010	62%	14%	10%	3%	4%	8%
2011	60%	17%	7%	4%	1%	11%
2012	58%	20%	7%	4%	6%	5%
2013	69%	7%	7%	4%	1%	13%
Average	56%	17%	10%	6%	4%	7%

Figure 10 - Number of dealers by revenue percent-dependence on small-mesh multispecies

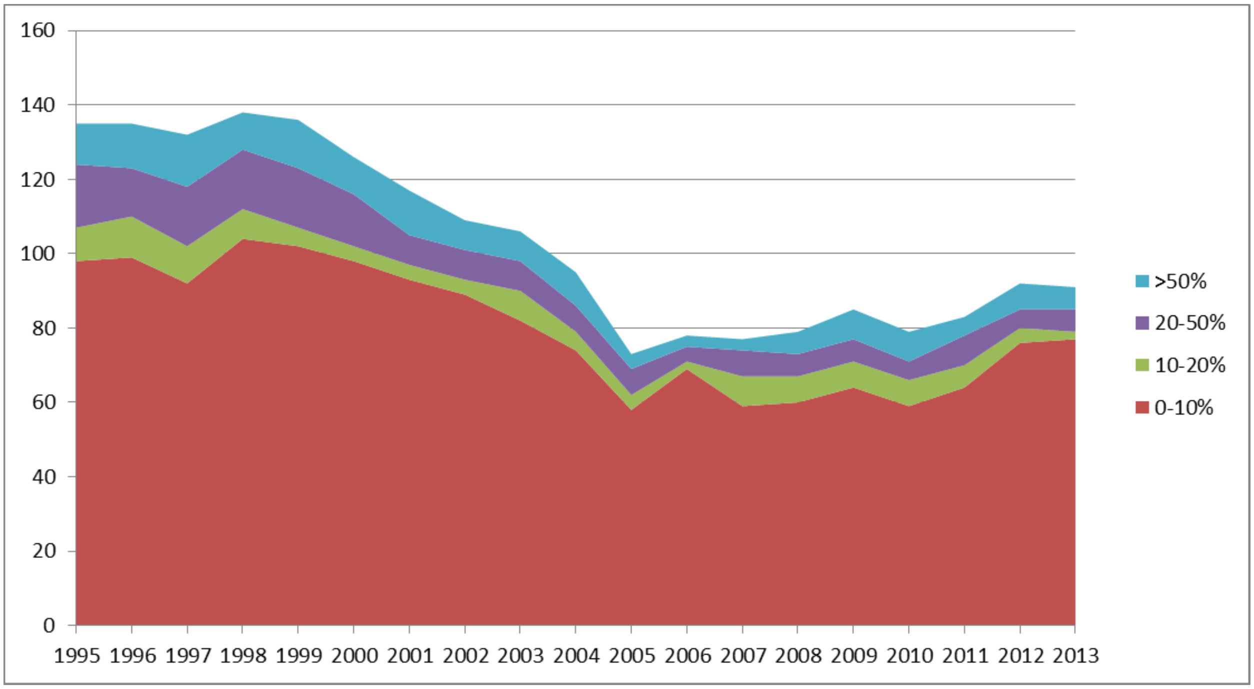


Table 16 - Annual proportion of dealers reporting small-mesh multispecies by percent dependence category.

Calendar year	0-10%	10-20%	20-50%	>50%
1995	73%	7%	13%	8%
1996	73%	8%	10%	9%
1997	70%	8%	12%	11%
1998	75%	6%	12%	7%
1999	75%	4%	12%	10%
2000	78%	3%	11%	8%
2001	79%	3%	7%	10%
2002	82%	4%	7%	7%
2003	77%	8%	8%	8%
2004	78%	5%	7%	9%
2005	79%	5%	10%	5%
2006	88%	3%	5%	4%
2007	77%	10%	9%	4%
2008	76%	9%	8%	8%
2009	75%	8%	7%	9%
2010	75%	9%	6%	10%
2011	77%	7%	10%	6%
2012	83%	4%	5%	8%
2013	85%	2%	7%	7%
Average	78%	6%	9%	8%

6.5 Trends in Landings

Over the time series, the Southern Management Area has averaged approximately 80 percent of the total landings of small-mesh multispecies and 82 percent of the average nominal revenues (Table 17). Landings and nominal revenues were much higher at the beginning of the time series, dropped off in the early 2000's, rose slightly until 2010, and have decreased slightly in the most recent three years. (Figure 11) As reported by industry members, there does appear to be some relationship between the revenues generated from the squid fishery (Longfin and *Illex*, combined) with landings of small-mesh multispecies, such that in years with higher squid revenues, there were fewer small-mesh multispecies landings (Figure 12).

As shown in Figure 13, the price per pound appears to be higher in more recent years than earlier in the time series, as adjusted for inflation.

Figure 11 - Small-mesh multispecies revenue and landings by stock area

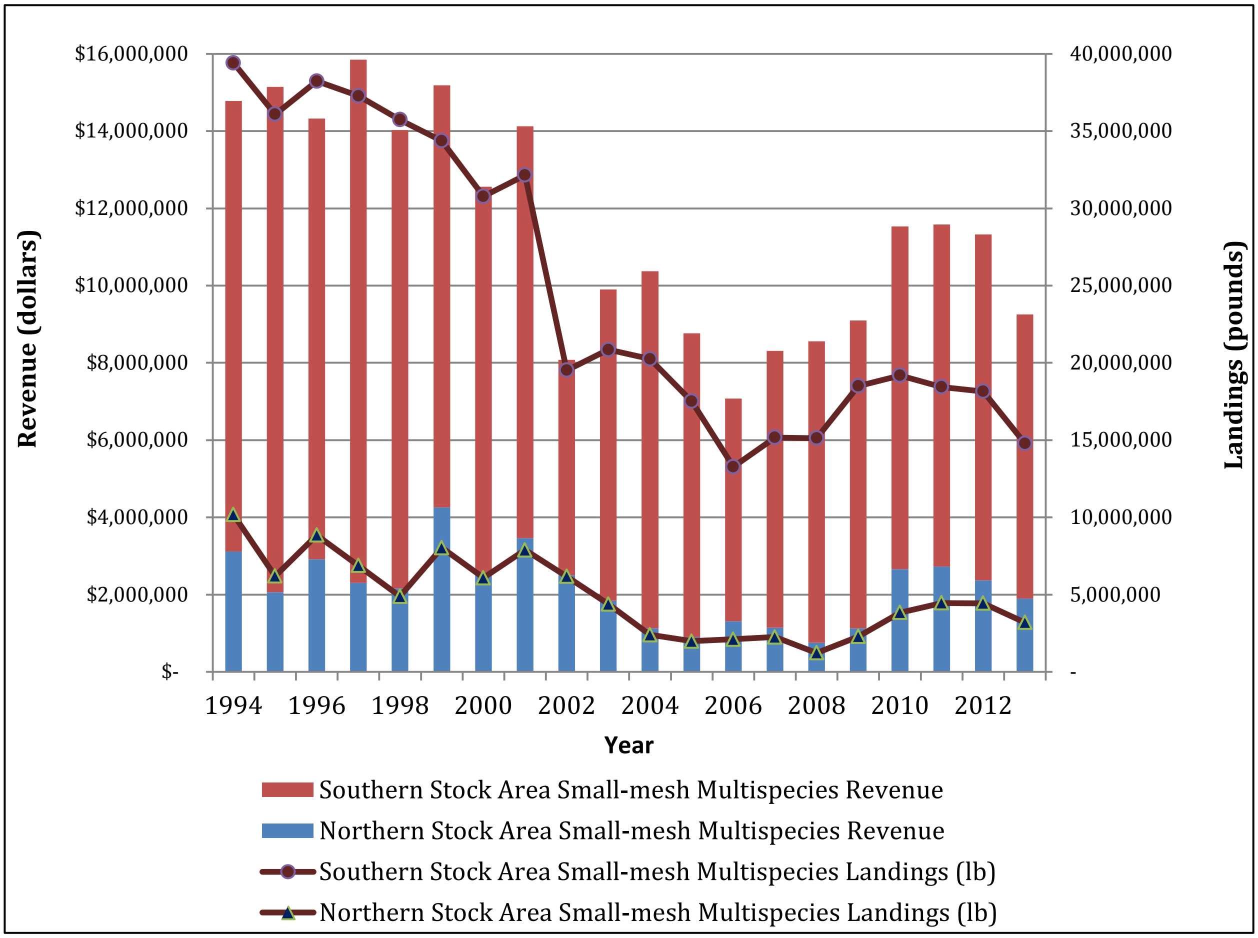


Table 17 - Small-mesh multispecies revenue and landings by stock area

	Northern Stock Area Revenue		Southern Stock Area Revenue		Total Revenue	Northern Stock Area Landings (lb)		Southern Stock Area Landings (lb)		Total Landings (lb)
1994	$3,117,633	21%	$11,659,716	79%	$14,777,349	10,177,145	26%	29,227,870	74%	39,405,015
1995	$2,061,589	14%	$13,079,218	86%	$15,140,807	6,207,227	17%	29,873,688	83%	36,080,915
1996	$2,916,236	20%	$11,410,356	80%	$14,326,592	8,850,997	23%	29,379,847	77%	38,230,844
1997	$2,302,082	15%	$13,546,640	85%	$15,848,722	6,885,970	18%	30,389,849	82%	37,275,819
1998	$2,163,531	15%	$11,864,147	85%	$14,027,678	4,889,806	14%	30,837,838	86%	35,727,644
1999	$4,261,250	28%	$10,922,901	72%	$15,184,151	8,036,403	23%	26,333,671	77%	34,370,074
2000	$2,500,264	20%	$10,058,457	80%	$12,558,721	6,093,574	20%	24,675,855	80%	30,769,429
2001	$3,467,618	25%	$10,658,165	75%	$14,125,783	7,886,656	25%	24,262,162	75%	32,148,818
2002	$2,500,995	31%	$5,581,551	69%	$8,082,546	6,186,408	32%	13,327,434	68%	19,513,842
2003	$1,842,937	19%	$8,056,325	81%	$9,899,262	4,392,621	21%	16,465,806	79%	20,858,427
2004	$1,130,785	11%	$9,238,371	89%	$10,369,156	2,401,395	12%	17,850,056	88%	20,251,451
2005	$905,957	10%	$7,858,430	90%	$8,764,387	1,983,527	11%	15,525,597	89%	17,509,124
2006	$1,312,401	19%	$5,764,568	81%	$7,076,969	2,112,433	16%	11,166,404	84%	13,278,837
2007	$1,146,992	14%	$7,160,053	86%	$8,307,045	2,258,560	15%	12,913,878	85%	15,172,438
2008	$754,850	9%	$7,800,884	91%	$8,555,734	1,233,887	8%	13,892,388	92%	15,126,275
2009	$1,124,576	12%	$7,973,097	88%	$9,097,673	2,293,147	12%	16,212,916	88%	18,506,063
2010	$2,657,599	23%	$8,876,890	77%	$11,534,489	3,842,272	20%	15,342,278	80%	19,184,550
2011	$2,724,154	24%	$8,856,862	76%	$11,581,016	4,460,644	24%	13,982,530	76%	18,443,174
2012	$2,367,837	21%	$8,960,154	79%	$11,327,991	4,437,236	24%	13,718,450	76%	18,155,686
2013	$1,899,198	21%	$7,357,861	79%	$9,257,059	3,195,603	22%	11,589,744	78%	14,785,347
Total	**$43,158,484**	**18%**	**$186,684,646**	**82%**	**$229,843,130**	**97,825,511**	**20%**	**396,968,261**	**80%**	**494,793,772**

Figure 12 - Small-mesh and squid revenue

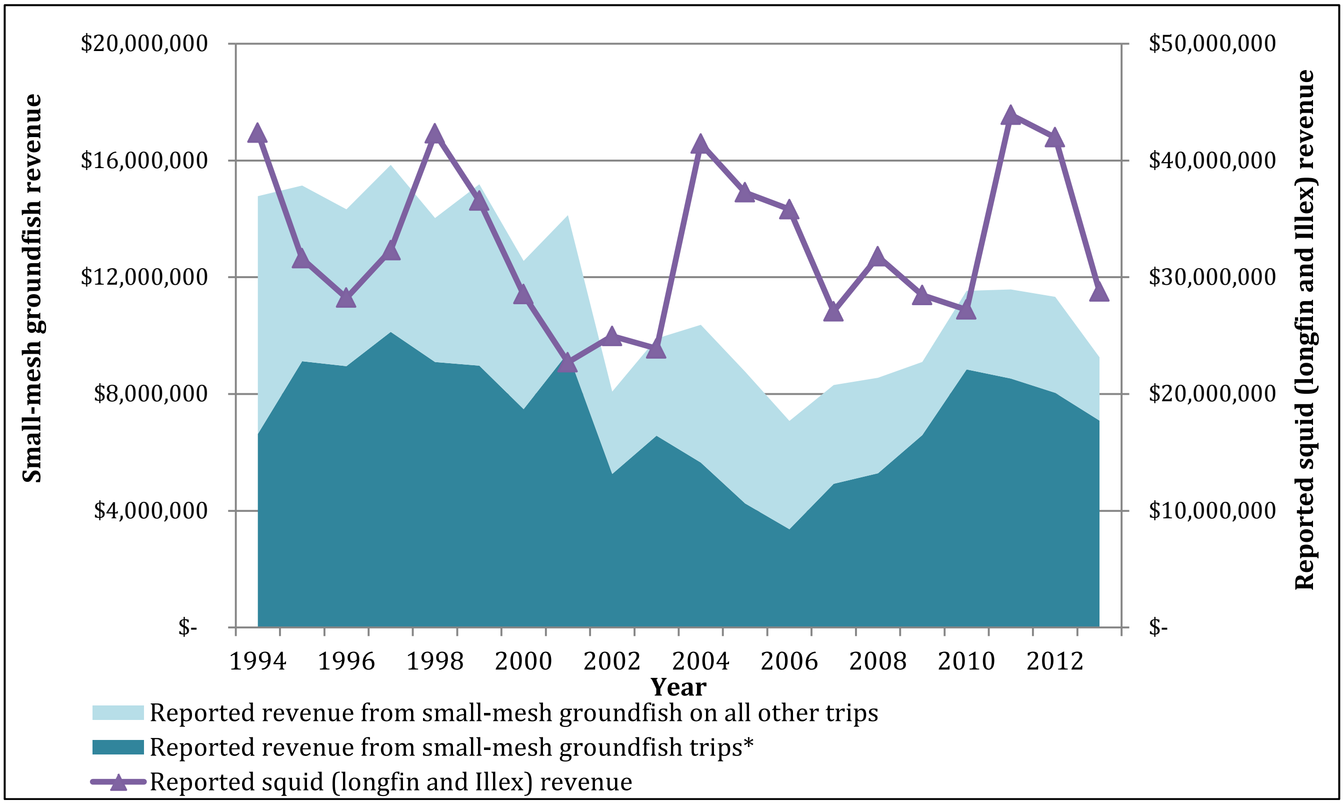


Figure 13 - Calendar year annual average dockside price vs. landings volume from small-mesh multispecies **directed trips** (more than 50% of dealer-reported revenue from the trip was derived from small-mesh multispecies) during 1994-2013.

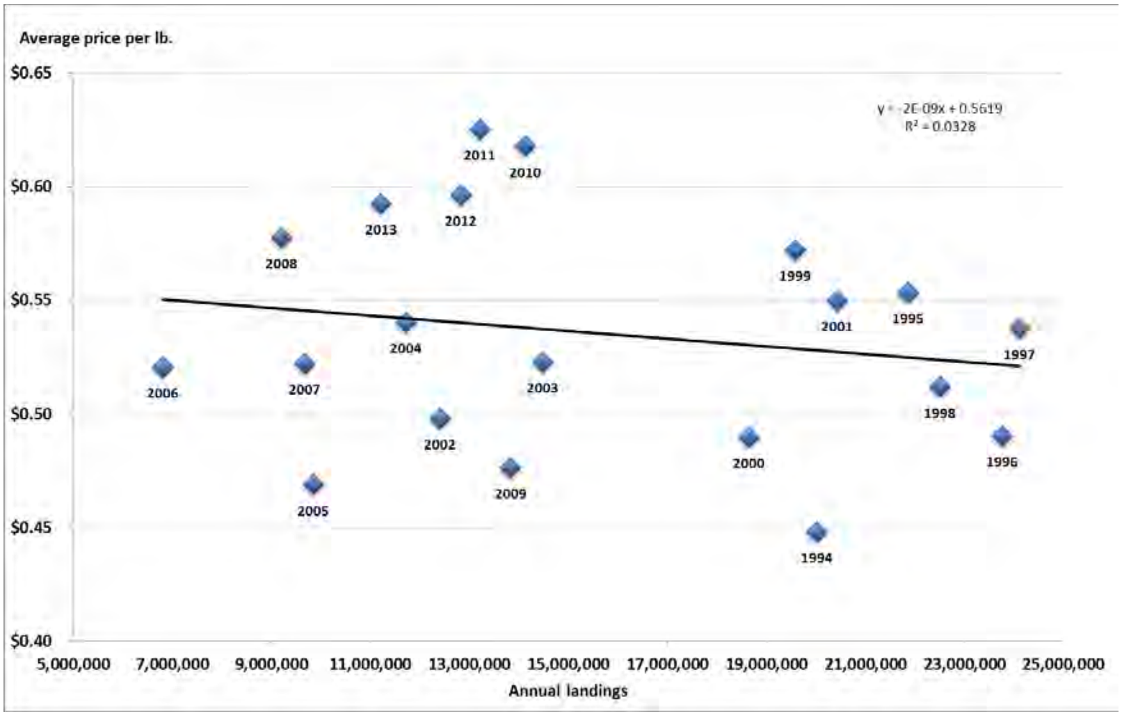
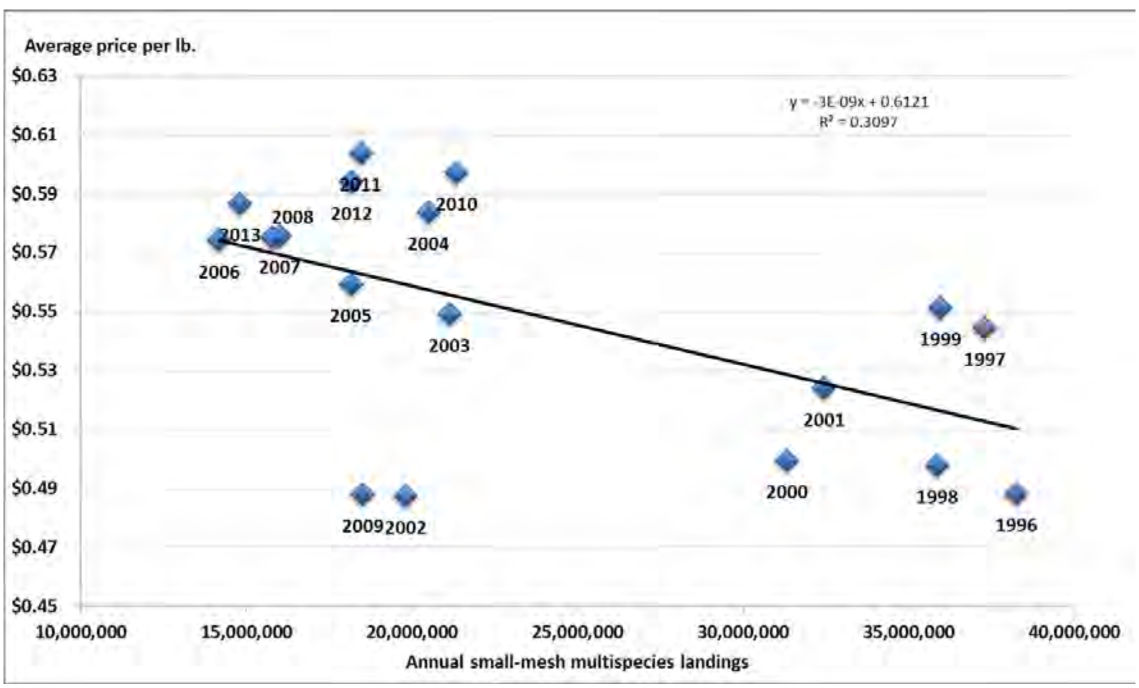


Figure 14 - Calendar year annual average dockside price vs. landings volume from small-mesh multispecies **all trips** landing small mesh multispecies during 1994-2013.



6.6 Groundfish and Northern Red Hake Bycatch Analysis

The Whiting PDT ran two types of analyses of groundfish catch rates in and surrounding (i.e. in the same statistical area) the existing small-mesh exemption areas on observed trips during 2008-2013. The purpose of these analyses were to determine whether adjustments are warranted to seasons or areas where small-mesh fishing is allowed, since a considerable amount of time has passed since groundfish bycatch rates had been analyzed (references???) and conditions may have changed.
The small-mesh exemption area seasons are listed in the table below.

Table 18 - 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					Sept 1 – Nov 20							
RFT[†]					September 1 – December 31							

Since this analysis of observed tows was begun, the update assessment determined that overfishing was occurring for northern red hake. A majority of northern red hake catch came from discards (and secondarily landings) in the small-mesh fishery. If additional management measures are needed to reduce the risk of future overfishing, this analysis was extended to include catches of red hake in the exemption areas by vessels using small-mesh trawls. Potential explanatory variables that are significant could identify ways that the Council could reduce northern red hake catch by restricting fishing activity in specific areas or months.

One type of analysis focused on catches by the small-mesh fishery within the exemption areas. No attempt was made to analyze the catches from various types of nets and configurations because the sample size was too small to analyze the various (and sometimes ambiguous) net types and configurations. Main effects considered were exemption area, month, year, plus a month*year interaction term. The model was fit to catch/kept-all ratios for the following species or species groups: cod, multispecies roundfish, multispecies flatfish, and red hake.

Catch to Kept-all ratios were and typically are highly skewed or even overdispersed with large numbers of observations at low values and a few number of high valued catch rates. This condition presents challenges and often invalidates parametric General Linear Models. To properly handle the skewed distribution, the GENMOD (reference???) procedure was applied assuming a negative binomial distribution of the data.

For each species group, an attempt to fit the catch/kept-all data was made using a fully-saturated model including all main effects plus a year*month interaction term. If the model converged on a solution and the year*month interaction term was not significant, then a 'best-fit' model was attempted using only the significant explanatory variables. Both models were also compared to a null model having only an intercept term to determine whether the fully-saturated model or the 'best-fit' model were better based on comparison of the full log-likelihood and AIC values. In some cases, the null or fully-saturated models did not converge on a solution and were therefore not used in the comparison.

6.6.1 Small-mesh trawl bycatch

6.6.1.1 Red hake in the small-mesh fishery

Neither the null model (Table 19) nor the saturated model (Table 20) for red hake converged. Despite this, the analysis determined that exemption area was the only statistically significant variable. A 'best-fit' model with only exemption area as the explanatory variable (Table 21) was significant. An alternative model with exemption area and month was attempted but did not converge on a solution.

Taking into account the main effects, there appear to be a difference in red hake catch rates between areas, but incorporation of month did not improve the model fit (which in fact failed to converge on a solution). The mean values and confidence intervals of red hake catch rates by exemption area is shown in Figure 15. The Cultivator Shoals area had the highest red hake catch rates, followed by Raised Footrope Trawl Area 1 and Small mesh Area 1.

Figure 15. Mean values and confidence intervals of red hake catch rates in the small mesh fishery from 2008-2013, by exemption area.

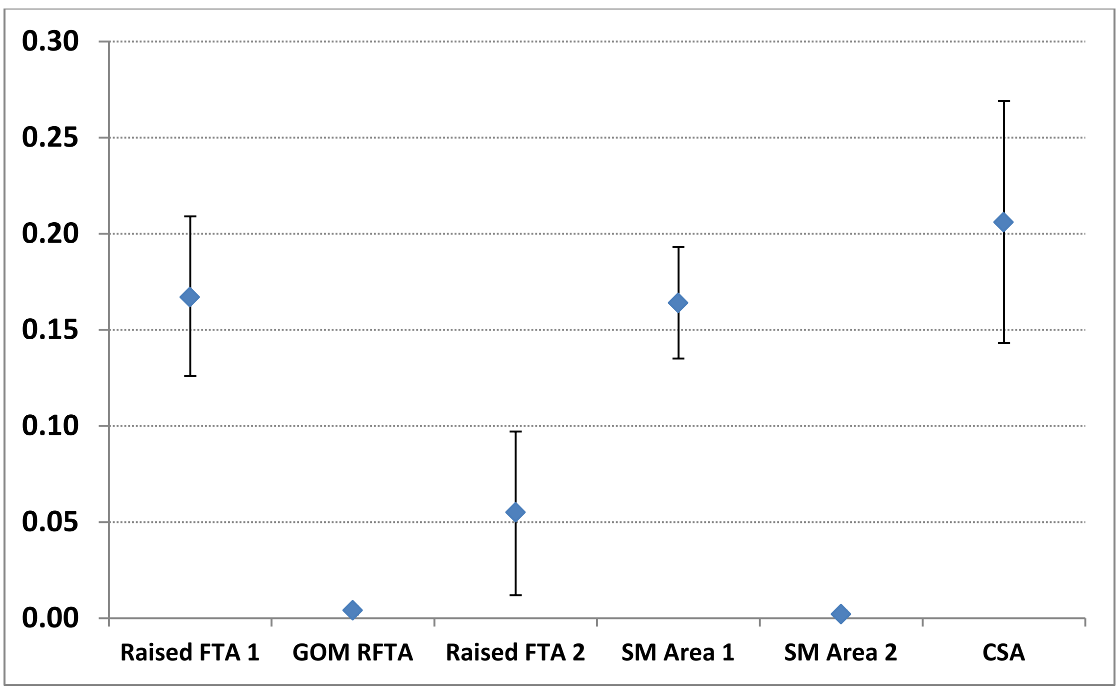


Table 19. Fully-saturated model fit to red hake catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	780	237.0006	0.3038
Scaled Deviance	780	237.0006	0.3038
Pearson Chi-Square	780	382.2103	0.4900
Scaled Pearson X2	780	382.2103	0.4900
Log Likelihood		-316.4840	
Full Log Likelihood		-298.0980	
AIC (smaller is better)		608.1960	
AICC (smaller is better)		608.3040	
BIC (smaller is better)		636.1901	

WARNING: The relative Hessian convergence criterion of 2.3610923562 is greater than the limit of 0.0001. The convergence is questionable.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	279.5219	337.3697	-381.711	940.7544	0.69	0.4074
month_obs	1	-23.1633	41.0916	-103.701	57.3747	0.32	0.5730
objectid_1	1	0.1367	0.0525	0.0337	0.2396	6.77	0.0093
year_obs	1	-0.1409	0.1678	-0.4698	0.1880	0.70	0.4012
month_obs*year_obs	1	0.0116	0.0204	-0.0285	0.0517	0.32	0.5704
Dispersion	0	0.0000	0.0000	0.0000	0.0000		

Table 20. Null model (no main effects) fit to red hake catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	784	266.7824	0.3403
Scaled Deviance	784	266.7824	0.3403
Pearson Chi-Square	784	483.3000	0.6165
Scaled Pearson X2	784	483.3000	0.6165
Log Likelihood		-331.3748	
Full Log Likelihood		-312.9889	
AIC (smaller is better)		629.9778	
AICC (smaller is better)		629.9931	
BIC (smaller is better)		639.3091	

WARNING: The relative Hessian convergence criterion of 1.5859051456 is greater than the limit of 0.0001. The convergence is questionable.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-1.9413	0.0942	-2.1259	-1.7566	424.58	<.0001
Dispersion	0	0.0000	0.0000	0.0000	0.0000		

Table 21. ‘Best fit’ model fit to red hake catch in the small mesh fishery during 2008-2013. ‘Objectid_1’ represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	783	261.6966	0.3342
Scaled Deviance	783	261.6966	0.3342
Pearson Chi-Square	783	441.3020	0.5636
Scaled Pearson X2	783	441.3020	0.5636
Log Likelihood		-328.8320	
Full Log Likelihood		-310.4460	
AIC (smaller is better)		626.8920	
AICC (smaller is better)		626.9227	
BIC (smaller is better)		640.8890	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-2.4348	0.2505	-2.9257	-1.9439	94.49	<.0001
objectid_1	1	0.1257	0.0565	0.0149	0.2366	4.95	0.0262
Dispersion	1	0.0000	0.0003	.	.		

An alternative set of explanatory variables were used in another attempt to fit a model to the red hake catch/kept all data. The mesh size and trawl type (raised footrope trawl or other) on each observed haul, as well as the year of the observed haul, were implemented as explanatory variables. The catch rates of red hake in the exemption area by net type are displayed in Table 22. The frequency of mesh sizes on small-mesh trips in the exemption areas is displayed in Figure 16. The fully saturated model did not converge (Table 23). Two alternative models were attempted, one accounting for mesh size and one accounting for the usage of a raised footrope trawl. Neither of the alternative models converged, indicating that red hake catch does not significantly differ across mesh size or trawl type.

Table 22. Catch rates of red hake in the exemption areas from 2008-2013, by net type.

The SAS System

The MEANS Procedure

Analysis Variable : red_hake_catch RED_HAKE_CATCH						
NETTYPELIST	N Obs	N	Mean	Std Dev	Minimum	Maximum
2-Seam Trawl	45	45	0.2510498	0.4061545	0	1.6591376
4-Seam Trawl	25	25	0.2846743	0.4831556	0	2.1092885
Balloon Trawl, 2-Seam	4	4	0.000776398	0.0015528	0	0.0031056
Box Trawl, 4-Seam	71	71	0.1914390	0.4306843	0	2.9611902
Flatfish Trawl, 2-Seam	22	22	0.0045376	0.0119096	0	0.0552677
Flatfish Trawl, 4-Seam	1	1	0	.	0	0
Flynet, 2-Seam	5	5	0.0473339	0.0348306	0.0153846	0.0911854
Groundfish Trawl	1	1	0	.	0	0
Groundfsh Trawl,2-Seam	63	63	0.0469350	0.1107337	0	0.5832349
Groundfsh Trawl,4-Seam	24	24	0.2240200	0.3154184	0	1.1736175
Hadd Separator, 2-Seam	12	12	0.000127136	0.000246899	0	0.000741021
Other (Comment)	23	23	0.3662927	0.7885106	0	2.6474747
Raised Footrope Trawl	65	65	0.2288301	0.2007776	0	0.6859584
Raised Footrope,2-Seam	158	158	0.1863977	0.2269479	0	1.2500000
Raised Footrope,4-Seam	49	49	0.1937929	0.3050958	0	1.8357143
Shrimp Trawl	18	18	0.0053028	0.0150516	0	0.0555556
Shrimp Trawl, 2-Seam	163	163	0.0201669	0.0990570	0	0.8109195
Shrimp Trawl, 4-Seam	4	4	0.0110000	0.0128062	0	0.0240000
Unknown	32	32	0.1972111	0.2708772	0	0.9408805

Figure 16 - Frequency distribution of mesh sizes used on small-mesh trips in the exemption areas from 2008-2013.

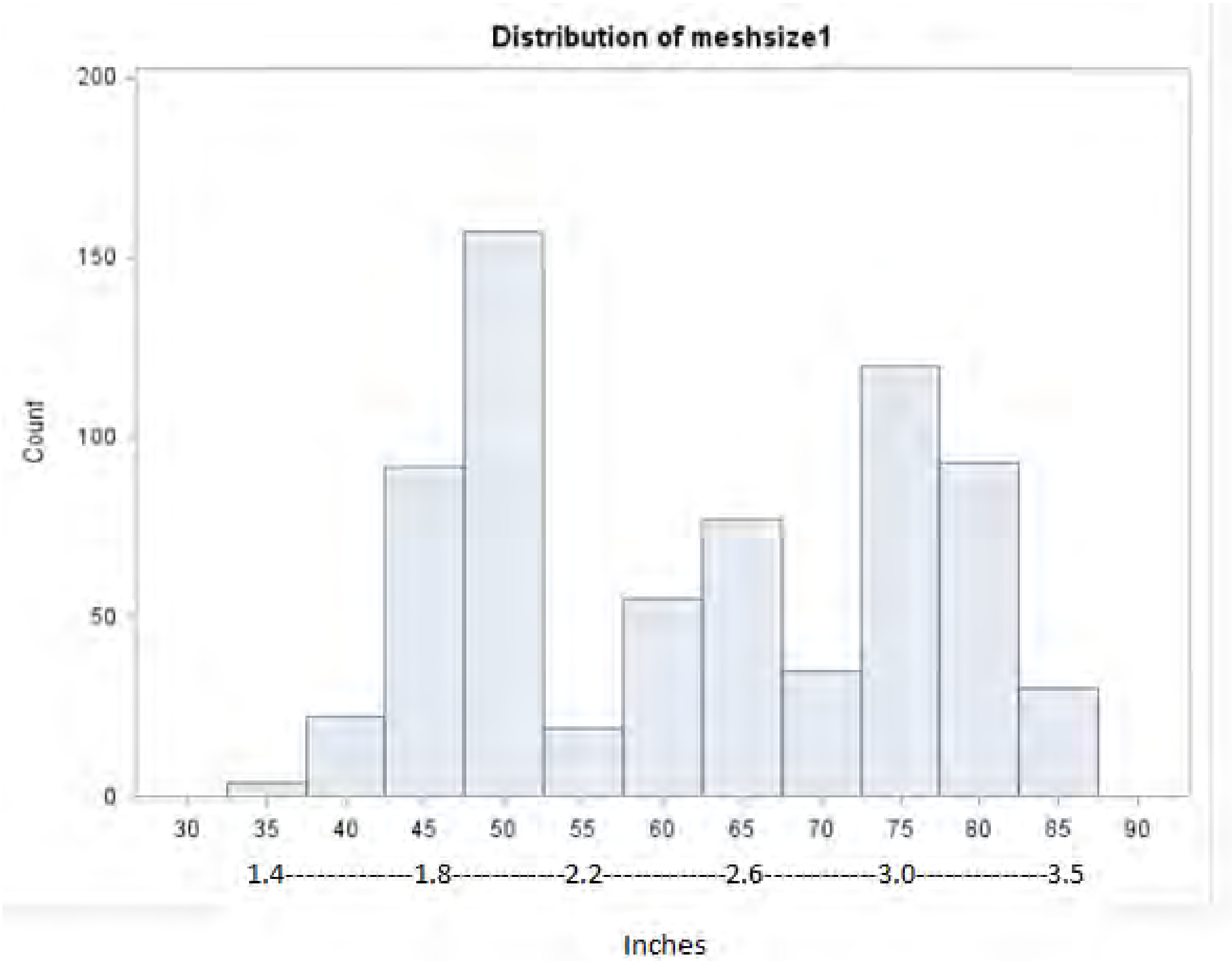


Table 23 – Fully saturated model fit to red hake catch in the small and large-mesh fisheries from 2008-2013. 'Objectid_1' represents the exemption area and 'meshsize' represents the use of a raised footrope trawl or a different trawl.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	PROJECT.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	red_hake_catch	RED_HAKE_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	781	253.0215	0.3240
Scaled Deviance	781	253.0215	0.3240
Pearson Chi-Square	781	524.8287	0.6720
Scaled Pearson X2	781	524.8287	0.6720
Log Likelihood		-324.4944	
Full Log Likelihood		-306.1084	
AIC (smaller is better)		622.2169	
AICC (smaller is better)		622.2939	
BIC (smaller is better)		645.5453	

WARNING: The relative Hessian convergence criterion of 4.6353876809 is greater than the limit of 0.0001. The convergence is questionable.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	276.2614	131.6866	18.1604	534.3623	4.40	0.0359
meshsize	1	0.0046	0.0039	-0.0031	0.0122	1.37	0.2420
nettypelist1	1	0.6763	0.1988	0.2867	1.0659	11.57	0.0007
year_obs	1	-0.1387	0.0655	-0.2671	-0.0103	4.48	0.0343
Dispersion	0	0.0000	0.0000	0.0000	0.0000		

6.6.1.2 Cod in the small mesh fishery

Both the null model (Table 24) and the saturated model (Table 25) for cod converged. The analysis determined that exemption area was the only statistically significant variable. A 'best fit' model with only exemption area as an explanatory variable (Table 26) was significant when compared against the null model and the saturated model.

According to the 'best fit' model, there appears to be a difference in cod catch between exemption areas. The mean values and confidence intervals of cod catch rates by exemption area are shown in Figure 17. The Cultivator Shoals area had the highest cod catch rates, followed by both Raised Footrope Trawl areas.

Figure 17. Mean values and confidence intervals of cod catch rates in the small mesh fishery from 2008-2013, by exemption area.

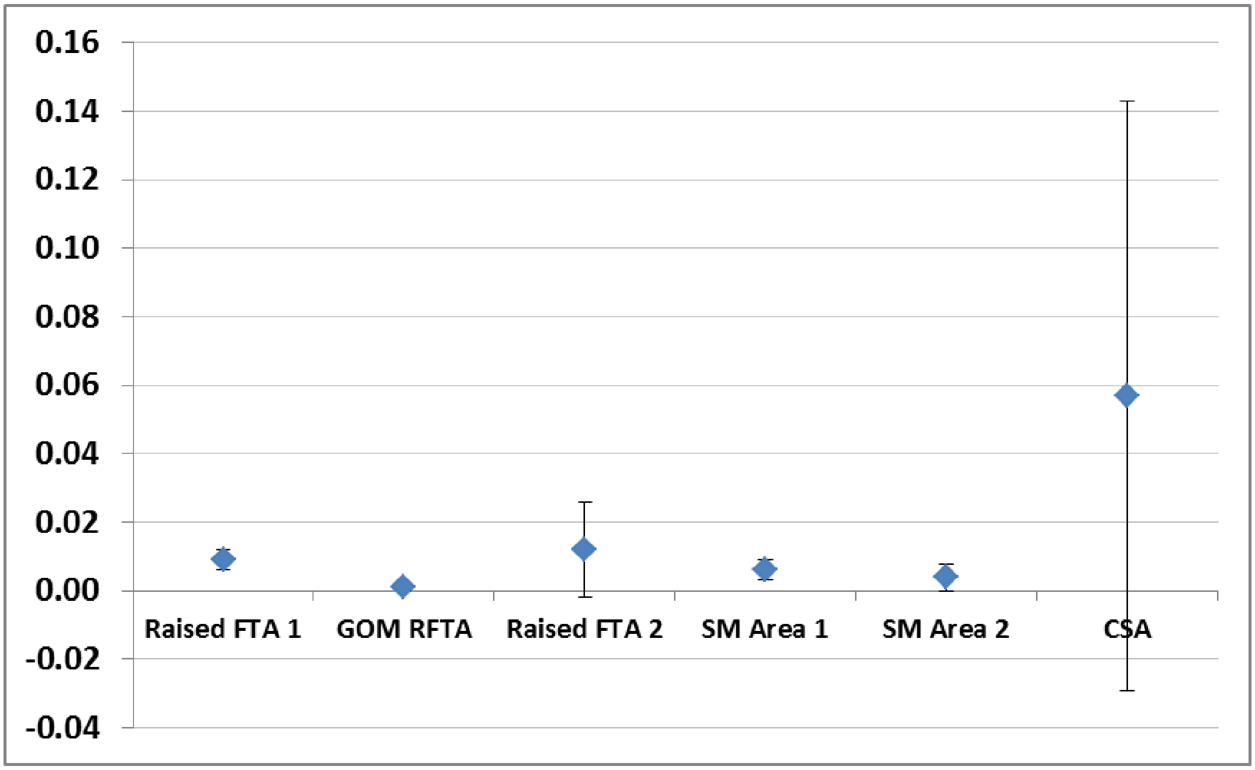


Table 24 - Null model fit to cod catch in the small mesh fishery during 2008-2013.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cod_catch	COD_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	784	87.8735	0.1121
Scaled Deviance	784	87.8735	0.1121
Pearson Chi-Square	784	3704.8087	4.7255
Scaled Pearson X2	784	3704.8087	4.7255
Log Likelihood		-64.5076	
Full Log Likelihood		-73.3667	
AIC (smaller is better)		150.7335	
AICC (smaller is better)		150.7488	
BIC (smaller is better)		160.0648	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-3.9600	0.2633	-4.4760	-3.4440	226.22	<.0001
Dispersion	1	1.9584	0.8146	0.8666	4.4255		

Table 25 - Fully-saturated model fit to cod catch in the small mesh fishery during 2008-2013.
'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cod_catch	COD_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	780	74.8411	0.0960
Scaled Deviance	780	74.8411	0.0960
Pearson Chi-Square	780	1369.1774	1.7554
Scaled Pearson X2	780	1369.1774	1.7554
Log Likelihood		-57.5531	
Full Log Likelihood		-66.4122	
AIC (smaller is better)		144.8245	
AICC (smaller is better)		144.9325	
BIC (smaller is better)		172.8186	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	359.9621	662.1578	-937.843	1657.767	0.30	0.5867
month_obs	1	24.1447	107.6066	-186.760	235.0499	0.05	0.8225
objectid_1	1	0.6240	0.2247	0.1836	1.0644	7.71	0.0055
year_obs	1	-0.1823	0.3294	-0.8279	0.4634	0.31	0.5801
month_obs*year_obs	1	-0.0120	0.0535	-0.1170	0.0929	0.05	0.8220
Dispersion	1	1.8459	0.7748	0.8109	4.2023		

Table 26 - 'Best fit' model fit to cod catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cod_catch	COD_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	783	76.6414	0.0979
Scaled Deviance	783	76.6414	0.0979
Pearson Chi-Square	783	1443.3369	1.8433
Scaled Pearson X2	783	1443.3369	1.8433
Log Likelihood		-58.5214	
Full Log Likelihood		-67.3806	
AIC (smaller is better)		140.7611	
AICC (smaller is better)		140.7919	
BIC (smaller is better)		154.7582	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-6.9159	1.1765	-9.2219	-4.6099	34.55	<.0001
objectid_1	1	0.6472	0.2215	0.2131	1.0814	8.54	0.0035
Dispersion	1	1.8634	0.7803	0.8201	4.2340		

6.6.1.3 Roundfish in the small-mesh fishery

Both the null model for roundfish (Table 27) and the saturated model (Table 28) converged. The saturated model indicated that exemption area was the only statistically significant variable. An alternative model with exemption area as the only explanatory variable was attempted but did not fit as well as the saturated model did. Therefore, the saturated model is also the 'best fit' model for small mesh roundfish.

The mean values and confidence intervals of roundfish catch rates by month of the observed haul are displayed in Figure 4. The highest catch rates of roundfish in the small-mesh fishery appear to occur in June, April and July. This conclusion could be misleading however, due to the lower number of observed small-mesh hauls in the sea sampling data.

Figure 18. Mean values and confidence intervals of roundfish catch rates in the small mesh fishery from 2008-2013 inside the exemption areas, by month of observed haul. The mean value in June was 21.8 and there was no observed catch in May.

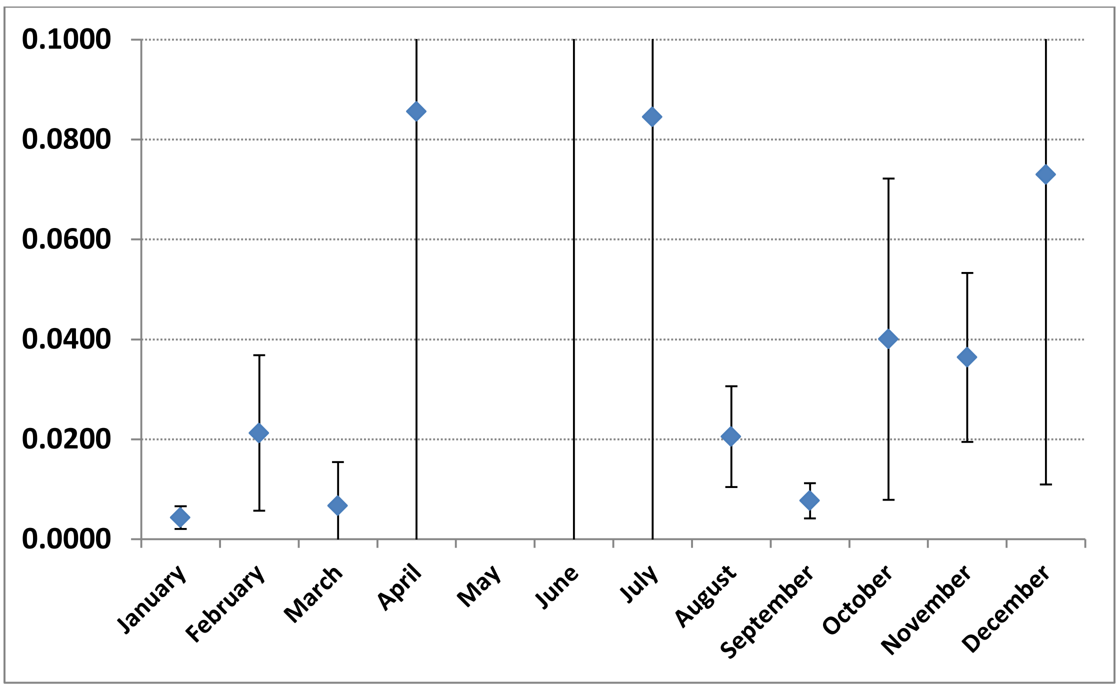


Figure 19. Predicted values and confidence intervals of roundfish catch rates in the Raised Footrope Trawl Area (Sept-Nov) by the small mesh fishery using sea sampling data from 2012, by exemption area.

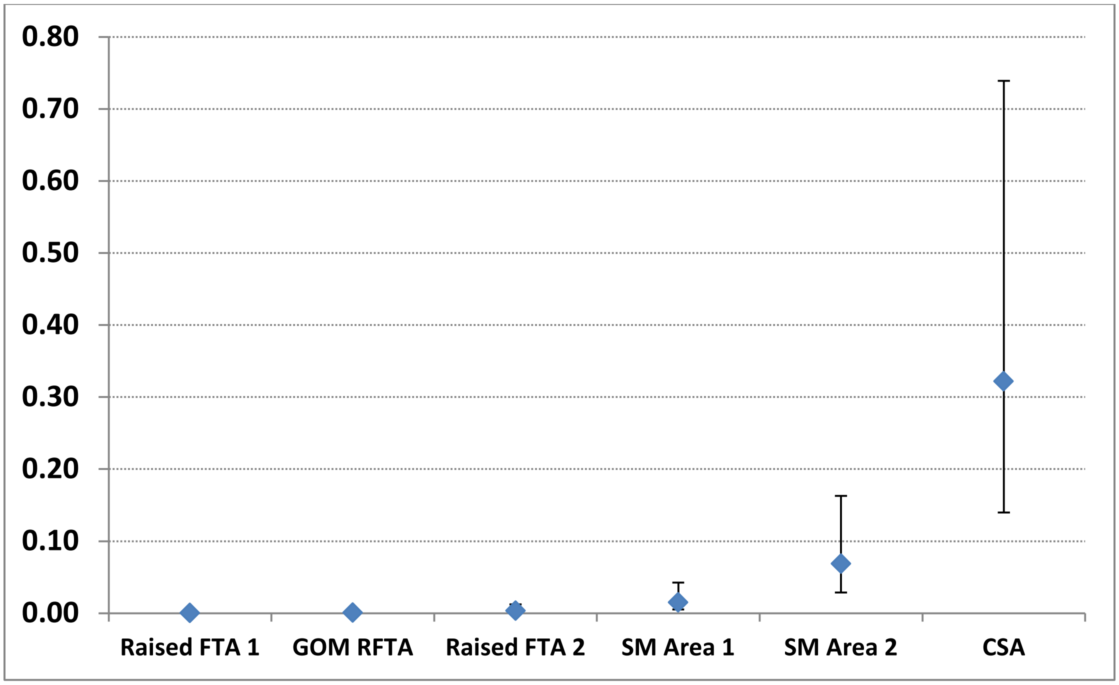


Table 27 - Null model fit to roundfish catch in the small mesh fishery during 2008-2013.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cods_catch	CODS_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	784	236.8704	0.3021
Scaled Deviance	784	236.8704	0.3021
Pearson Chi-Square	784	25624.6544	32.6845
Scaled Pearson X2	784	25624.6544	32.6845
Log Likelihood		409.9827	
Full Log Likelihood		-280.1176	
AIC (smaller is better)		564.2353	
AICC (smaller is better)		564.2506	
BIC (smaller is better)		573.5666	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-1.3779	0.1473	-1.6665	-1.0893	87.56	<.0001
Dispersion	1	13.0543	1.4378	10.5197	16.1995		

Table 28 - Fully-saturated model fit to roundfish catch in the small mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cods_catch	CODS_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	780	186.0661	0.2385
Scaled Deviance	780	186.0661	0.2385
Pearson Chi-Square	780	5946.2058	7.6233
Scaled Pearson X2	780	5946.2058	7.6233
Log Likelihood		479.5078	
Full Log Likelihood		-210.5926	
AIC (smaller is better)		433.1851	
AICC (smaller is better)		433.2931	
BIC (smaller is better)		461.1792	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	895.7850	522.9951	-129.266	1920.836	2.93	0.0867
month_obs	1	-95.7122	86.4708	-265.192	73.7675	1.23	0.2683
objectid_1	1	1.5773	0.2076	1.1704	1.9842	57.72	<.0001
year_obs	1	-0.4497	0.2601	-0.9596	0.0601	2.99	0.0838
month_obs*year_obs	1	0.0475	0.0430	-0.0368	0.1318	1.22	0.2693
Dispersion	1	6.4022	0.8894	4.8761	8.4058		

6.6.1.4 Flatfish in the small-mesh fishery

The null model for flatfish converged (Table 29) while the saturated model did not. An alternative model was attempted, designating the month of the observed haul and the year*month interaction term as explanatory variables. This model provided more robust results and was a better fit than the null model for flatfish, therefore the alternative model is also the 'best fit' model (Table 30). Since the saturated model did not converge, the refined model could not be compared to it.

The 'best fit' model indicates there is a significant difference in flatfish catch rates between months of the observed hauls. The mean values and confidence intervals of flatfish catch rates in the small mesh fishery are displayed in Figure 20. The catch rates of flatfish were highest in June, followed by November and then September.

Figure 20. Mean values and confidence intervals of flatfish catch rates in the small mesh fishery from 2008-2013, by month of observed haul

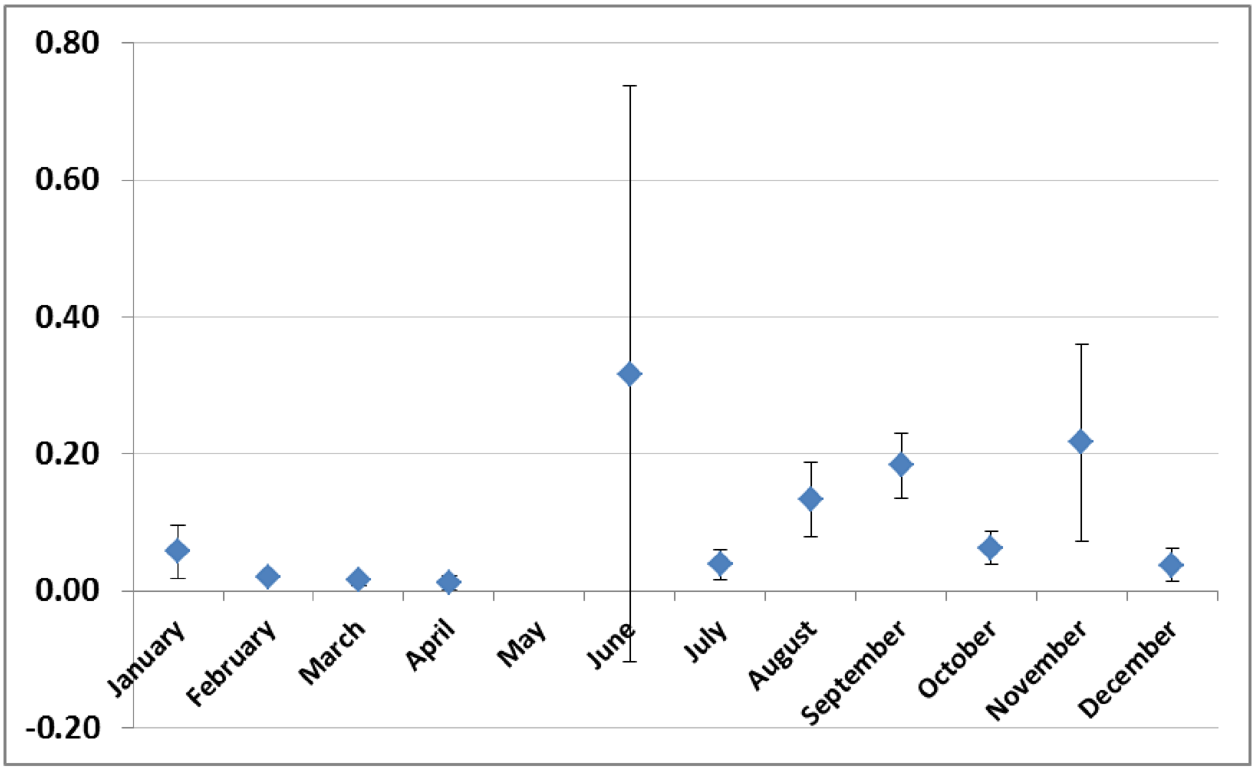


Table 29 - Null model fit to flatfish catch in the small mesh fishery during 2008-2013.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	flatfish_catch	FLATFISH_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	784	200.6489	0.2559
Scaled Deviance	784	200.6489	0.2559
Pearson Chi-Square	784	487.7636	0.6221
Scaled Pearson X2	784	487.7636	0.6221
Log Likelihood		-257.7327	
Full Log Likelihood		-243.1447	
AIC (smaller is better)		490.2894	
AICC (smaller is better)		490.3047	
BIC (smaller is better)		499.6207	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-2.3110	0.1133	-2.5332	-2.0889	415.73	<.0001
Dispersion	1	0.0000	0.0004	.	.		

Table 30 - 'Best fit' model fit to flatfish catch in the small mesh fishery during 2008-2013.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.SM_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	flatfish_catch	FLATFISH_CATCH

Number of Observations Read	785
Number of Observations Used	785

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	782	181.1518	0.2317
Scaled Deviance	782	181.1518	0.2317
Pearson Chi-Square	782	426.8086	0.5458
Scaled Pearson X2	782	426.8086	0.5458
Log Likelihood		-247.9841	
Full Log Likelihood		-233.3961	
AIC (smaller is better)		474.7922	
AICC (smaller is better)		474.8435	
BIC (smaller is better)		493.4550	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-3.1524	0.3423	-3.8234	-2.4814	84.79	<.0001
month_obs	1	60.1738	21.1382	18.7437	101.6040	8.10	0.0044
month_obs*year_obs	1	-0.0299	0.0105	-0.0505	-0.0093	8.07	0.0045
Dispersion	1	0.0000	0.0004	.	.		

6.6.2 Large-mesh trawl bycatch of groundfish.

6.6.2.1 Cod in the large mesh fishery

The same analysis was applied to catch of cod, roundfish and flatfish in the large-mesh fishery. There were 15,182 observed hauls in the exemption areas from 2008-2013. The null model for cod did not converge, while the saturated model did (Table 31). An alternative model with just year of the observed haul as an explanatory variable was attempted but the results did not fit as well as the saturated model did. Therefore, the saturated model is the 'best fit' model for large mesh cod. Since the null model did not converge, the alternative model could not be compared to it.

The mean values and confidence intervals of cod catch rates by month of the observed haul are displayed in Figure 7. The highest catch rates of cod are in April, followed by December and then June.

Figure 21. Mean values and confidence intervals of cod catch rates in the large mesh fishery from 2008-2013 inside the exemption areas, by month of observed haul.

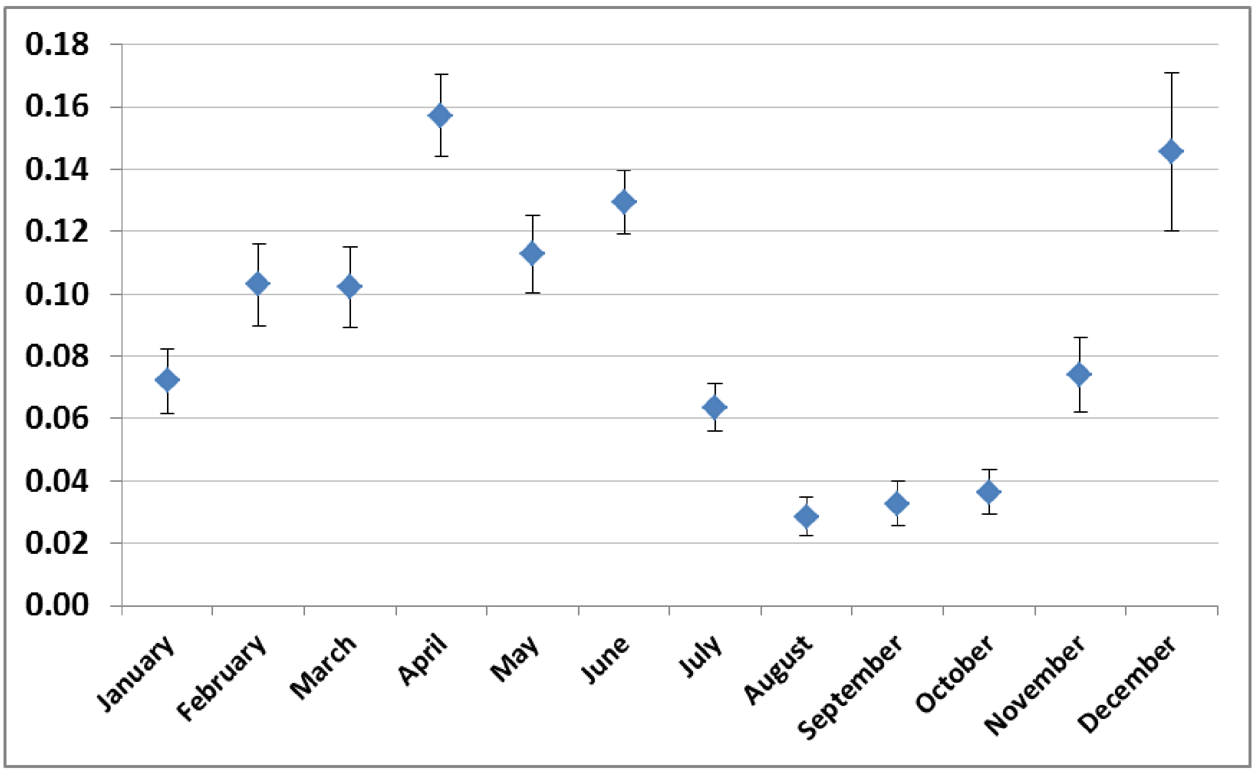


Table 31 - Fully-saturated model fit to cod catch in the large mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.LG_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cod_catch	COD_CATCH

Number of Observations Read	15162
Number of Observations Used	15162

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	15E3	3400.9615	0.2244
Scaled Deviance	15E3	3400.9615	0.2244
Pearson Chi-Square	15E3	6674.6568	0.4404
Scaled Pearson X2	15E3	6674.6568	0.4404
Log Likelihood		-4299.4644	
Full Log Likelihood		-3986.5836	
AIC (smaller is better)		7985.1671	
AICC (smaller is better)		7985.1726	
BIC (smaller is better)		8030.9264	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	1109.947	79.6220	953.8907	1266.003	194.33	<.0001
month_obs	1	-59.1347	11.9455	-82.5475	-35.7218	24.51	<.0001
objectid_1	1	-0.1878	0.0215	-0.2299	-0.1456	76.35	<.0001
year_obs	1	-0.5527	0.0396	-0.6304	-0.4751	194.68	<.0001
month_obs*year_obs	1	0.0294	0.0059	0.0177	0.0410	24.44	<.0001
Dispersion	1	0.0000	0.0003	0.0000	1.9E239		

6.6.2.2 Roundfish in the large mesh fishery

The null model for large mesh roundfish converged (Table 32) while the saturated model did not. An alternative model was attempted, using exemption area and the year of the observed haul as explanatory variables. This model provided more robust results and proved to be a better fit than the null model, proving it as the 'best fit' model for roundfish (Table 33). Since the saturated model did not converge, the alternative model could not be compared to it.

The mean values and confidence intervals of roundfish catch rates by month of the observed haul are displayed in Figure 8. Roundfish catch rates are higher in the first half of the year than the second half, with the highest catch rates occuring in April, followed by March and May.

Figure 22. Mean values and confidence intervals of roundfish catch rates in the large mesh fishery from 2008-2013 inside the exemption areas, by month of observed haul.

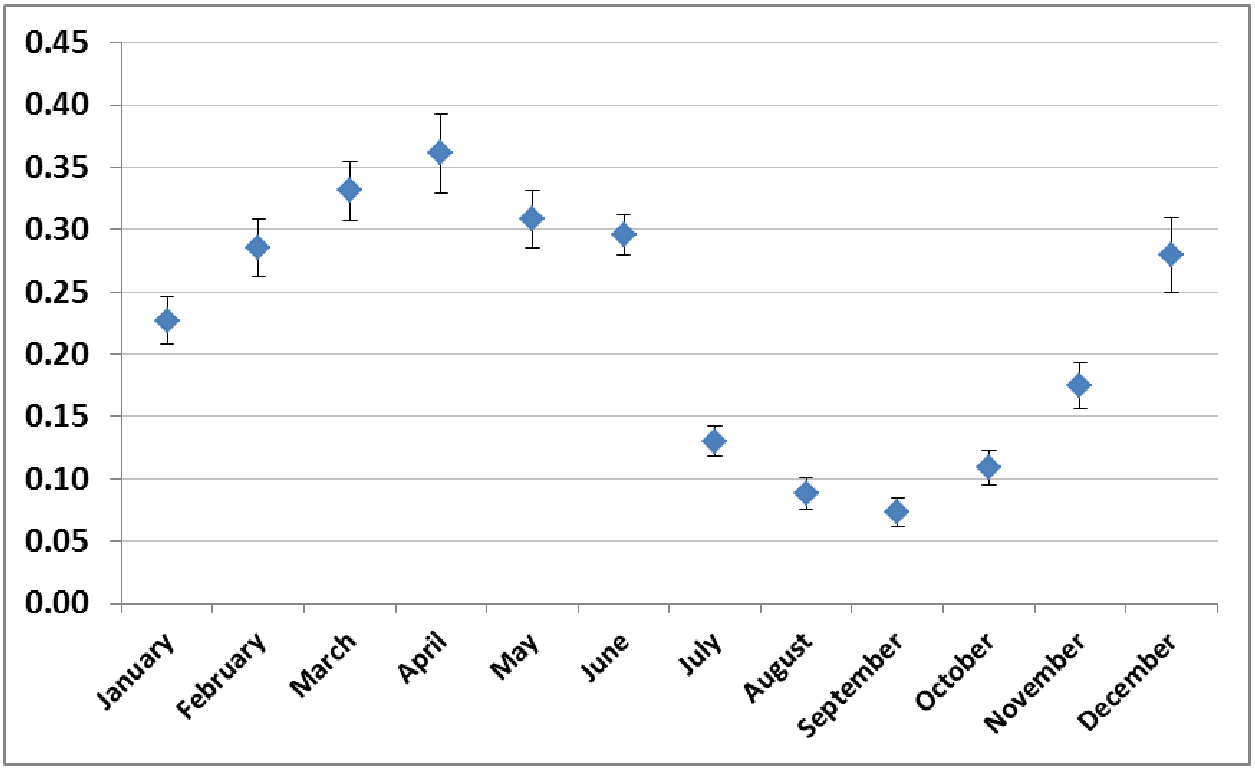


Table 32 - Null model fit to roundfish catch in the large mesh fishery during 2008-2013. 'Cods_catch represents the catch of roundfish.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.LG_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cods_catch	CODS_CATCH

Number of Observations Read	15162
Number of Observations Used	15162

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	15E3	7021.2796	0.4631
Scaled Deviance	15E3	7021.2796	0.4631
Pearson Chi-Square	15E3	9191.1001	0.6062
Scaled Pearson X2	15E3	9191.1001	0.6062
Log Likelihood		-8272.6375	
Full Log Likelihood		-7871.8161	
AIC (smaller is better)		15747.6322	
AICC (smaller is better)		15747.6330	
BIC (smaller is better)		15762.8853	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-1.5367	0.0175	-1.5710	-1.5024	7701.14	<.0001
Dispersion	1	0.0000	0.0005	.	.		

Table 33. 'Best fit' model fit to roundfish catch in the large mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas and 'cods_catch' represents the catch of roundfish.

The GENMOD Procedure

Model Information		
Data Set	DAVE.LG_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	cods_catch	CODS_CATCH

Number of Observations Read	15162
Number of Observations Used	15162

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	15E3	6421.9624	0.4236
Scaled Deviance	15E3	6421.9624	0.4236
Pearson Chi-Square	15E3	10040.5532	0.6623
Scaled Pearson X2	15E3	10040.5532	0.6623
Log Likelihood		-7972.9789	
Full Log Likelihood		-7572.1575	
AIC (smaller is better)		15152.3151	
AICC (smaller is better)		15152.3177	
BIC (smaller is better)		15182.8212	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	576.7328	24.3402	529.0268	624.4387	561.43	<.0001
objectid_1	1	-0.0599	0.0151	-0.0895	-0.0304	15.79	<.0001
year_obs	1	-0.2875	0.0121	-0.3113	-0.2638	564.53	<.0001
Dispersion	1	0.0000	0.0002	0.0000	1.29E195		

6.6.2.3 Flatfish in the large mesh fishery

Both the null model (Table 34) and saturated model (Table 35) for large mesh flatfish converged. An alternative model, with exemption area and year of the observed haul as explanatory variables, was attempted but it did not fit as well as the fully saturated model did. Therefore, the fully saturated model is the 'best fit' model for large mesh flatfish.

The mean values and confidence intervals of flatfish catch rates by month of the observed haul are displayed in Figure 9. Flatfish catch rates appear to steadily increase throughout the year, peaking in August and then decreasing in the remaining months.

Figure 23. Mean values and confidence intervals of flatfish catch rates in the large mesh fishery from 2008-2013 inside the exemption areas, by month of observed haul.

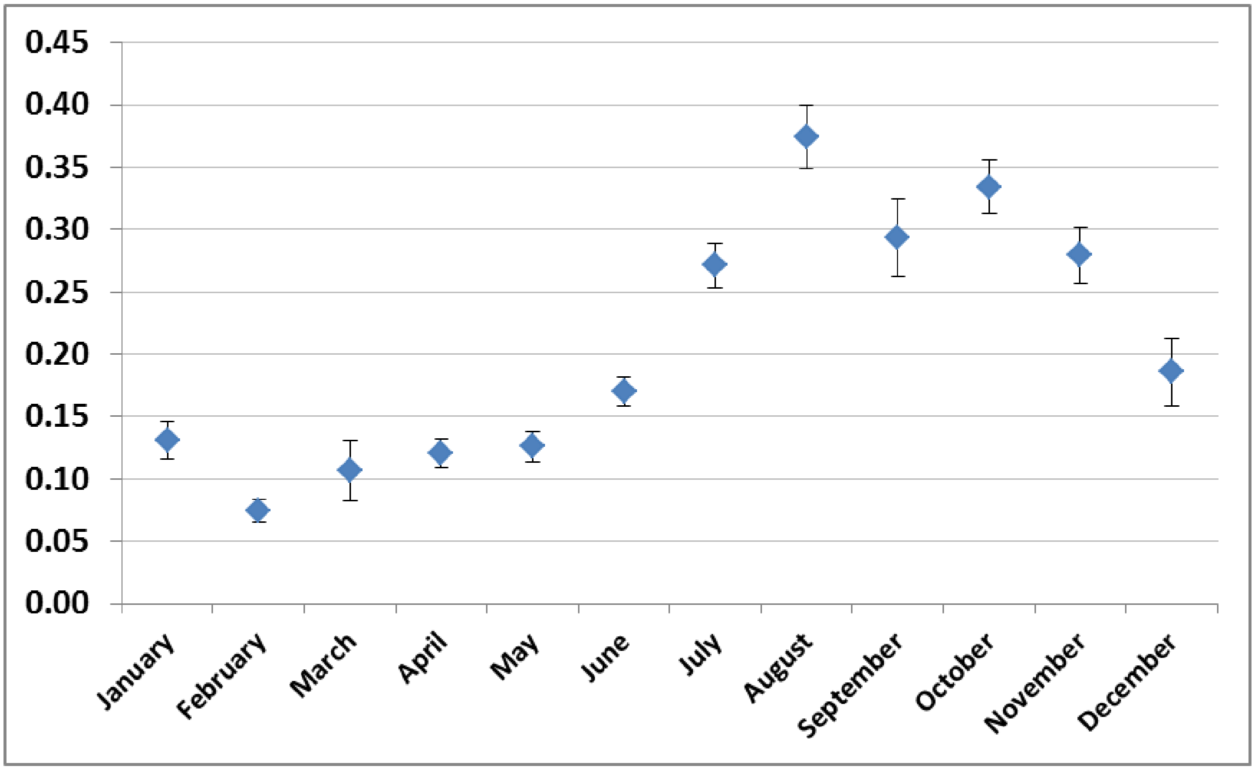


Table 34 - Null model fit to flatfish catch in the large mesh fishery during 2008-2013.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.LG_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	flatfish_catch	FLATFISH_CATCH

Number of Observations Read	15162
Number of Observations Used	15162

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	15E3	5962.3584	0.3933
Scaled Deviance	15E3	5962.3584	0.3933
Pearson Chi-Square	15E3	9917.1046	0.6541
Scaled Pearson X2	15E3	9917.1046	0.6541
Log Likelihood		-8266.6143	
Full Log Likelihood		-7838.5277	
AIC (smaller is better)		15681.0553	
AICC (smaller is better)		15681.0561	
BIC (smaller is better)		15696.3084	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	-1.5379	0.0175	-1.5722	-1.5036	7703.93	<.0001
Dispersion	1	0.0000	0.0002	0.0000	3.32E243		

Table 35 - Fully-saturated model fit to flatfish catch in the large mesh fishery during 2008-2013. 'Objectid_1' represents the various exemption areas.

The SAS System

The GENMOD Procedure

Model Information		
Data Set	DAVE.LG_MESH	
Distribution	Negative Binomial	
Link Function	Log	
Dependent Variable	flatfish_catch	FLATFISH_CATCH

Number of Observations Read	15162
Number of Observations Used	15162

Criteria For Assessing Goodness Of Fit			
Criterion	DF	Value	Value/DF
Deviance	15E3	4747.6762	0.3132
Scaled Deviance	15E3	4747.6762	0.3132
Pearson Chi-Square	15E3	7793.8443	0.5142
Scaled Pearson X2	15E3	7793.8443	0.5142
Log Likelihood		-7659.2732	
Full Log Likelihood		-7231.1866	
AIC (smaller is better)		14474.3731	
AICC (smaller is better)		14474.3787	
BIC (smaller is better)		14520.1324	

Algorithm converged.

Analysis Of Maximum Likelihood Parameter Estimates							
Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Wald Chi-Square	Pr > ChiSq
Intercept	1	488.6563	61.5194	368.0804	609.2322	63.09	<.0001
month_obs	1	26.9108	7.8590	11.5075	42.3141	11.73	0.0006
objectid_1	1	0.0616	0.0171	0.0280	0.0951	12.90	0.0003
year_obs	1	-0.2444	0.0306	-0.3043	-0.1844	63.75	<.0001
month_obs*year_obs	1	-0.0133	0.0039	-0.0210	-0.0057	11.65	0.0006
Dispersion	1	0.0000	0.0001	0.0000	3.03E174		

7.0 Fishery Cost Information

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.[7] 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.

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,

[7] 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.

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 36 - 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 37 - 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 38 - 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 39 - 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 40 - 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 41 - 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 42 - 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, as well as commercial fishery data from vessel trip reports, dealer landings records and on-board fishery observers updated through 2013. 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 2011-2013. For northern red hake, the three year moving average of the spring survey index for years 2012-2014 and exploitation index for years 2011-2013 were used in this assessment update. In the case of the southern red hake stock, spring 2014 index was excluded from this update due to survey not covering the full southern area therefore the three year average spring survey and exploitation indices for years 2011-2013 were used instead.

Silver hake

In both stocks of silver hake, the three year average fall biomass index (15.72kg/tow in the north vs 1.70kg/tow in the south) are both well above the overfished management threshold (3.21 kg/tow in the north vs 0.83kg/tow in the south), influenced by the recent observed increases in the fall survey trends. The exploitation index measured as the ratio of catch to survey has remained consistently low since the previous benchmark assessment and well below (0.14 kt/kg in the north vs 3.86 kt/kg in the south) the management overfishing definition thresholds (2.78 kt/kg in the north vs 34.17 kt/kg in the south). Hence 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 red hake assessment update indicates that both stocks are not overfished. However, overfishing is occurring in the northern stock while overfishing is not occurring in the southern stock of red hake. The recent three year arithmetic mean biomass index based on the NEFSC spring bottom trawl survey for the northern stock (2012-2014 = 2.03 kg/tow) and southern stock (2011-2013 = 2.42 kg/tow) were both above the proposed management threshold (1.27 kg/tow in the north vs 0.51 kg/tow in the south). The recent three year average exploitation index (0.170 kt/kg) was just above the management threshold in the north (0.163 kt/kg) and below (1.320 kt/kg) the management threshold in the south (3.038 kt/kg; Table 45 and Table 46**;** Figure 27**,** Figure 28 and Figure 29).

Table 43 - ***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 fall survey biomass the relative exploitation ratio from 2011-2013.

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
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

Table 44 - ***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 fall survey biomass the relative exploitation ratio from 2011-2013.

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
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

Figure 24 - ***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 20 years of the entire time series.

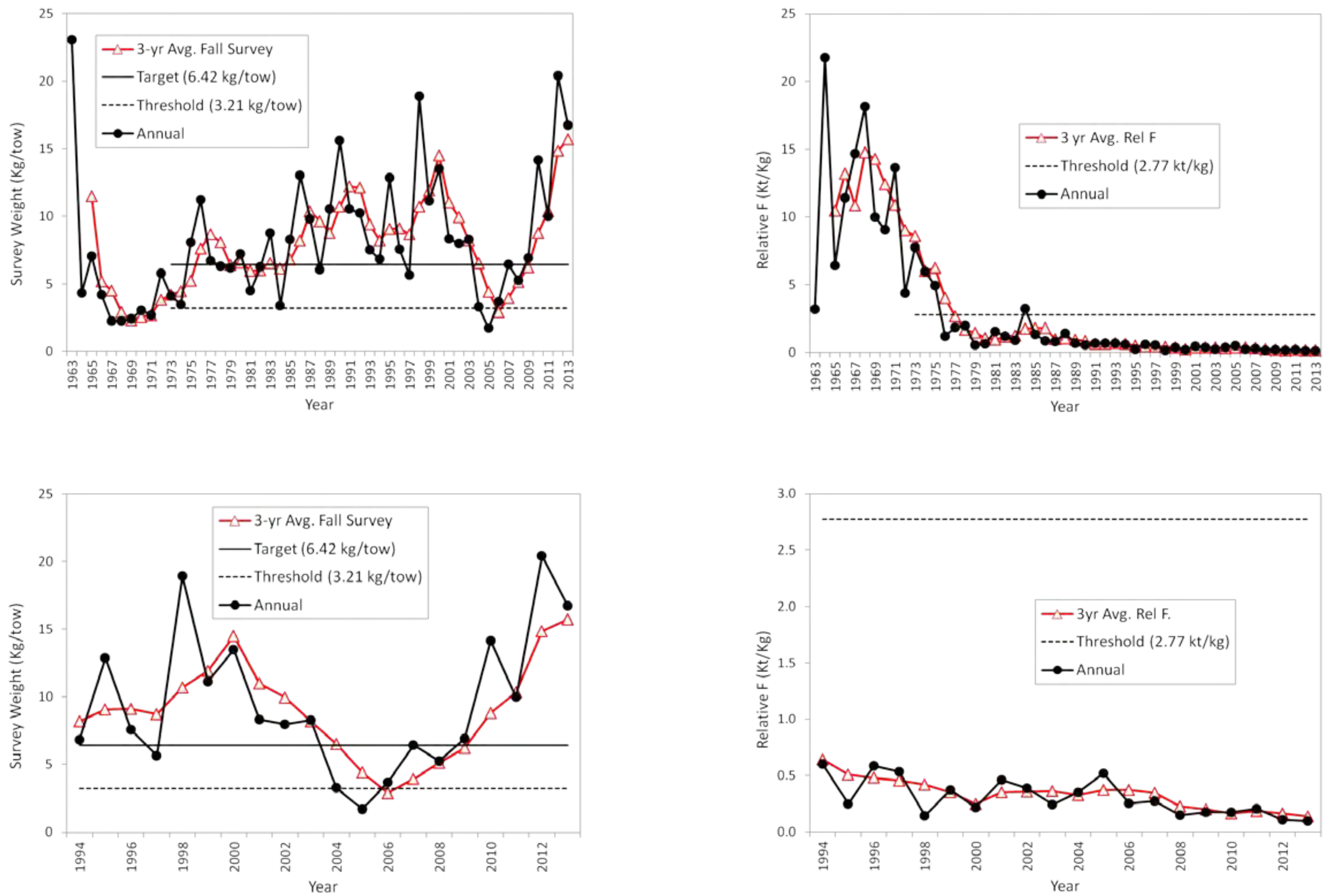


Figure 25 - ***Southern silver hake*** fall survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the fall survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 20 years of the entire time series

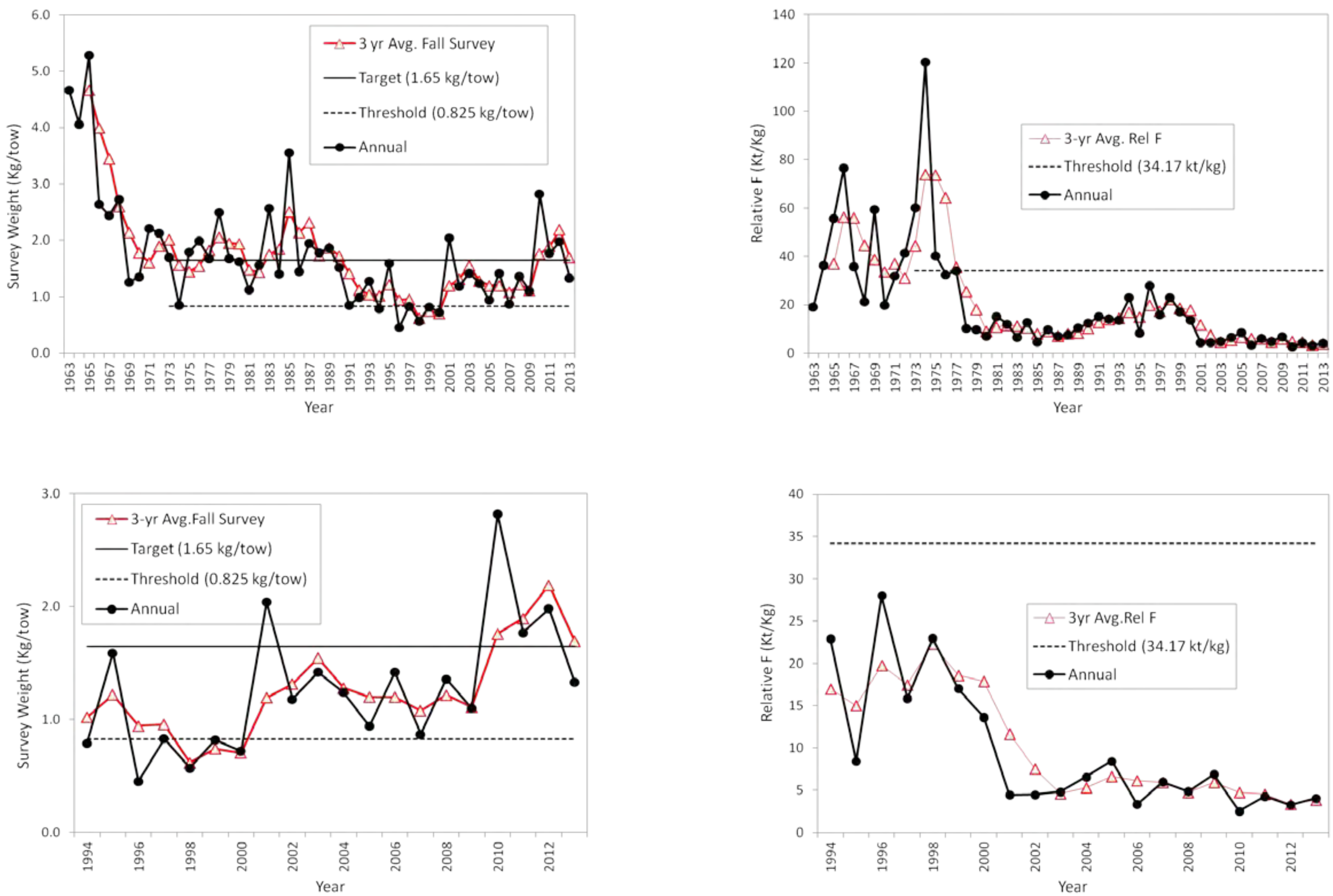


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Figure 26 - Silver hake biomass and fishing stock status plots for specification years 2012-2014 (labeled as 2010) and 2015-2017 (labeled as 2014) and associated 95% confidence intervals. The triangle and circle symbols are points estimates derived 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.

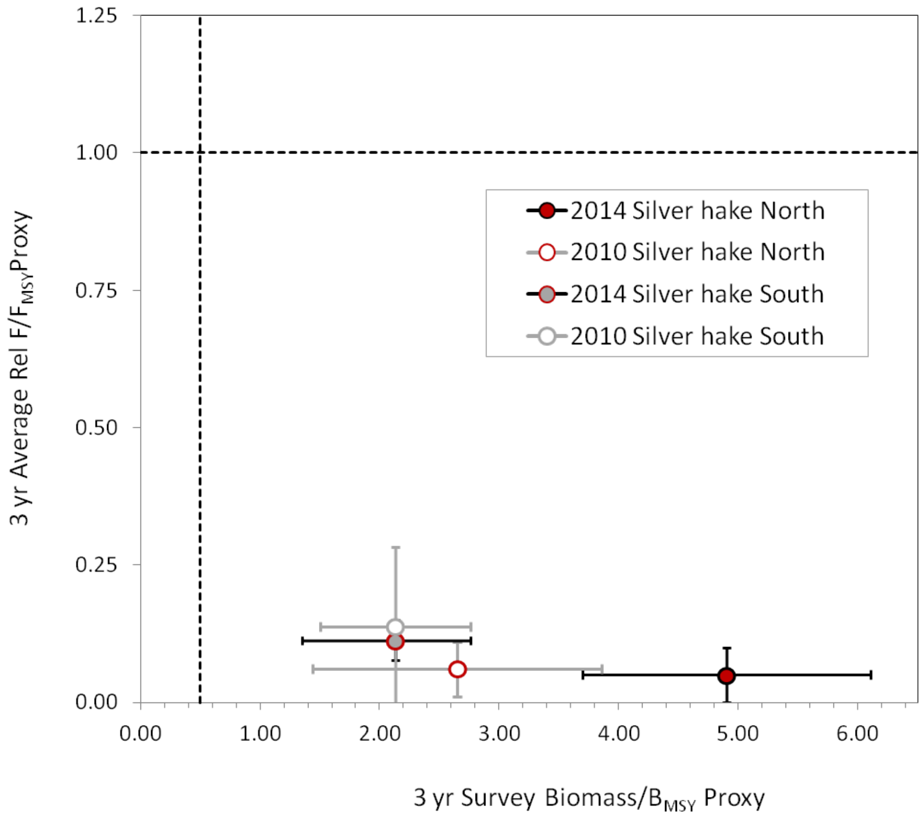

Table 45 - ***Northern red hake*** - Summary of total catch (kt), NEFSC spring survey biomass in albatross units (kg/tow) and index of relative exploitation ratios of total catch to the spring survey biomass (kt/kg) for northern red hake. Note: This assessment update was based on the most recent three year average of both the spring survey biomass (2012-2104) and the relative exploitation ratios from 2011-2013.

Year	Northern Spring Survey arithmetic kg/tow	Northern Spring Survey 3-year Average kg/tow	Total Northern Landings (000's mt)	Northern 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			3.79			3.79		
1961			3.28			3.28		
1962			1.91	1.60	0.01	3.52		
1963			3.28	1.60	0.00	4.89		
1964			1.41	1.70	0.00	3.11		
1965			2.77	1.62	0.00	4.40		
1966			5.58	1.60	0.00	7.18		
1967			1.86	1.40	0.00	3.27		
1968	1.14		2.63	1.30	0.00	3.93	3.45	
1969	0.64		2.02	1.12	0.00	3.14	4.91	
1970	0.54	0.77	1.03	1.10	0.00	2.13	3.94	4.10
1971	0.65	0.61	4.81	1.16	0.00	5.97	9.21	6.02
1972	1.56	0.92	15.03	0.96	0.00	15.99	10.25	7.80
1973	4.31	2.17	15.29	0.91	0.00	16.20	3.76	7.74
1974	2.43	2.77	7.22	0.82	0.00	8.04	3.31	5.77
1975	4.25	3.67	8.70	1.20	0.00	9.90	2.33	3.13
1976	3.37	3.35	6.34	0.93	0.00	7.26	2.15	2.60
1977	2.66	3.43	0.89	1.08	0.00	1.98	0.74	1.74
1978	2.57	2.87	1.22	1.12	0.00	2.34	0.91	1.27
1979	2.04	2.42	1.52	1.22	0.01	2.75	1.35	1.00
1980	3.88	2.83	1.03	1.37	0.00	2.40	0.62	0.96
1981	6.35	4.09	1.25	1.32	0.03	2.60	0.41	0.79
1982	2.13	4.12	1.21	1.46	0.00	2.67	1.26	0.76
1983	3.70	4.06	0.90	1.35	0.00	2.25	0.61	0.76
1984	2.98	2.94	1.06	1.33	0.00	2.39	0.80	0.89
1985	3.91	3.53	0.99	1.27	0.00	2.26	0.58	0.66
1986	3.26	3.39	1.46	1.19	0.00	2.65	0.81	0.73
1987	2.94	3.37	1.01	1.05	0.00	2.07	0.70	0.70
1988	2.00	2.73	0.86	0.90	0.00	1.76	0.88	0.80
1989	1.65	2.20	0.78	1.45	0.00	2.22	1.35	0.98
1990	1.33	1.66	0.83	0.60	0.00	1.43	1.07	1.10
1991	1.62	1.53	0.74	0.82	0.00	1.56	0.96	1.13
1992	2.50	1.82	0.92	0.73	0.00	1.65	0.66	0.90
1993	2.82	2.32	0.77	0.08	0.00	0.85	0.30	0.64
1994	1.59	2.31	0.73	0.08	0.00	0.81	0.51	0.49
1995	1.97	2.13	0.19	0.06	0.00	0.25	0.13	0.31
1996	1.79	1.79	0.41	0.66	0.01	1.07	0.60	0.41
1997	1.81	1.86	0.34	0.13	0.00	0.46	0.26	0.33
1998	2.52	2.04	0.19	0.13	0.00	0.32	0.13	0.33
1999	2.32	2.22	0.22	0.47	0.00	0.69	0.30	0.23
2000	3.19	2.68	0.20	0.06	0.00	0.25	0.08	0.17
2001	3.58	3.03	0.22	0.14	0.00	0.36	0.10	0.16
2002	4.46	3.74	0.28	0.10	0.00	0.38	0.08	0.09
2003	1.00	3.01	0.21	0.09	0.00	0.30	0.30	0.16
2004	1.77	2.41	0.10	0.06	0.00	0.16	0.09	0.16
2005	1.10	1.29	0.10	0.06	0.00	0.15	0.14	0.18
2006	0.91	1.26	0.10	0.18	0.00	0.28	0.30	0.18
2007	2.06	1.36	0.07	0.13	0.00	0.20	0.10	0.18
2008	3.49	2.15	0.05	0.06	0.00	0.11	0.03	0.14
2009	1.75	2.43	0.09	0.10	0.00	0.18	0.10	0.08
2010	2.02	2.42	0.07	0.24	0.00	0.31	0.15	0.10
2011	2.18	1.98	0.14	0.10	0.00	0.24	0.11	0.12
2012	1.73	1.98	0.10	0.19	0.00	0.29	0.17	0.14
2013	1.35	1.75	0.10	0.22	0.00	0.31	0.23	0.1691
2014	3.02	2.03						

Table 46 - ***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 (2011-2013) and the relative exploitation ratios from 2011-2013.

Year	Southern Spring Survey arithmetic kg/tow	Southern Spring Survey 3-year Average kg/tow	Total Southern Landings (000's mt)	Southern 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	0.89	16.76		
1963			31.90	4.00	0.77	36.67		
1964			43.37	3.76	0.85	47.98		
1965			92.99	4.29	0.63	97.92		
1966			107.92	3.77	0.09	111.79		
1967			58.78	3.66	0.17	62.61		
1968	1.29		18.14	3.72	0.58	22.43	17.45	
1969	1.08		52.93	3.62	0.49	57.04	52.72	
1970	1.72	1.36	11.45	3.14	0.41	15.01	8.71	26.29
1971	3.49	2.10	35.13	2.31	0.29	37.73	10.82	24.08
1972	3.59	2.93	61.19	2.10	0.18	63.47	17.68	12.40
1973	3.99	3.69	51.36	2.24	0.32	53.92	13.51	14.00
1974	2.84	3.47	26.64	2.16	0.19	28.99	10.22	13.80
1975	3.18	3.34	19.98	1.76	0.05	21.79	6.85	10.19
1976	5.31	3.78	22.47	1.83	0.65	24.94	4.69	7.25
1977	2.30	3.60	7.06	1.82	0.75	9.63	4.19	5.24
1978	7.65	5.09	5.46	2.44	0.97	8.87	1.16	3.35
1979	1.51	3.82	7.59	2.67	0.25	10.50	6.94	4.09
1980	2.38	3.85	4.08	2.70	0.14	6.93	2.91	3.67
1981	4.61	2.84	2.32	2.72	0.18	5.21	1.13	3.66
1982	3.34	3.45	3.17	3.78	0.03	6.98	2.09	2.04
1983	2.21	3.39	1.44	3.89	0.14	5.47	2.48	1.90
1984	1.33	2.29	1.27	3.91	0.55	5.73	4.30	2.96
1985	1.39	1.64	0.90	2.97	0.03	3.90	2.80	3.19
1986	1.73	1.49	0.69	3.39	0.21	4.29	2.47	3.19
1987	0.88	1.33	0.94	3.31	0.47	4.73	5.38	3.55
1988	1.01	1.21	0.87	3.46	0.25	4.58	4.56	4.14
1989	0.49	0.79	0.93	5.01	0.44	6.37	13.09	7.68
1990	0.71	0.73	0.80	4.75	0.51	6.06	8.57	8.74
1991	0.61	0.60	0.93	2.61	0.29	3.82	6.26	9.30
1992	0.47	0.59	1.25	6.34	0.19	7.78	16.74	10.52
1993	0.42	0.50	0.92	5.31	0.09	6.32	14.91	12.63
1994	0.68	0.52	0.98	1.72	0.07	2.77	4.11	11.92
1995	0.52	0.54	1.43	1.33	0.05	2.80	5.43	8.15
1996	0.45	0.55	0.70	0.38	0.02	1.10	2.43	3.99
1997	1.16	0.71	1.00	2.42	0.17	3.59	3.10	3.65
1998	0.21	0.61	1.15	0.74	0.05	1.95	9.10	4.87
1999	0.46	0.61	1.35	1.06	0.05	2.46	5.42	5.87
2000	0.42	0.36	1.42	0.25	0.04	1.71	4.04	6.19
2001	0.64	0.51	1.47	0.14	0.02	1.63	2.54	4.00
2002	0.54	0.54	0.66	0.33	0.01	1.00	1.85	2.81
2003	0.21	0.46	0.62	0.35	0.02	0.99	4.79	3.06
2004	0.15	0.30	0.59	0.62	0.01	1.21	7.88	4.84
2005	0.38	0.25	0.36	1.01	0.06	1.42	3.77	5.48
2006	0.38	0.30	0.38	0.67	0.05	1.10	2.90	4.85
2007	0.86	0.54	0.47	1.55	0.02	2.04	2.37	3.02
2008	0.47	0.57	0.58	0.81	0.07	1.47	3.10	2.79
2009	1.34	0.89	0.58	0.87	0.10	1.54	1.15	2.21
2010	0.92	0.91	0.58	0.74	0.09	1.41	1.52	1.93
2011	1.79	1.35	0.50	1.01	0.115	1.62	0.91	1.19
2012	1.06	1.26	0.75	0.65	0.037	1.44	1.36	1.26
2013	0.64	1.16	0.44	0.58	0.076	1.10	1.71	1.32
2014	0.73	NA						

Figure 27 - ***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 20 years of the entire time series.

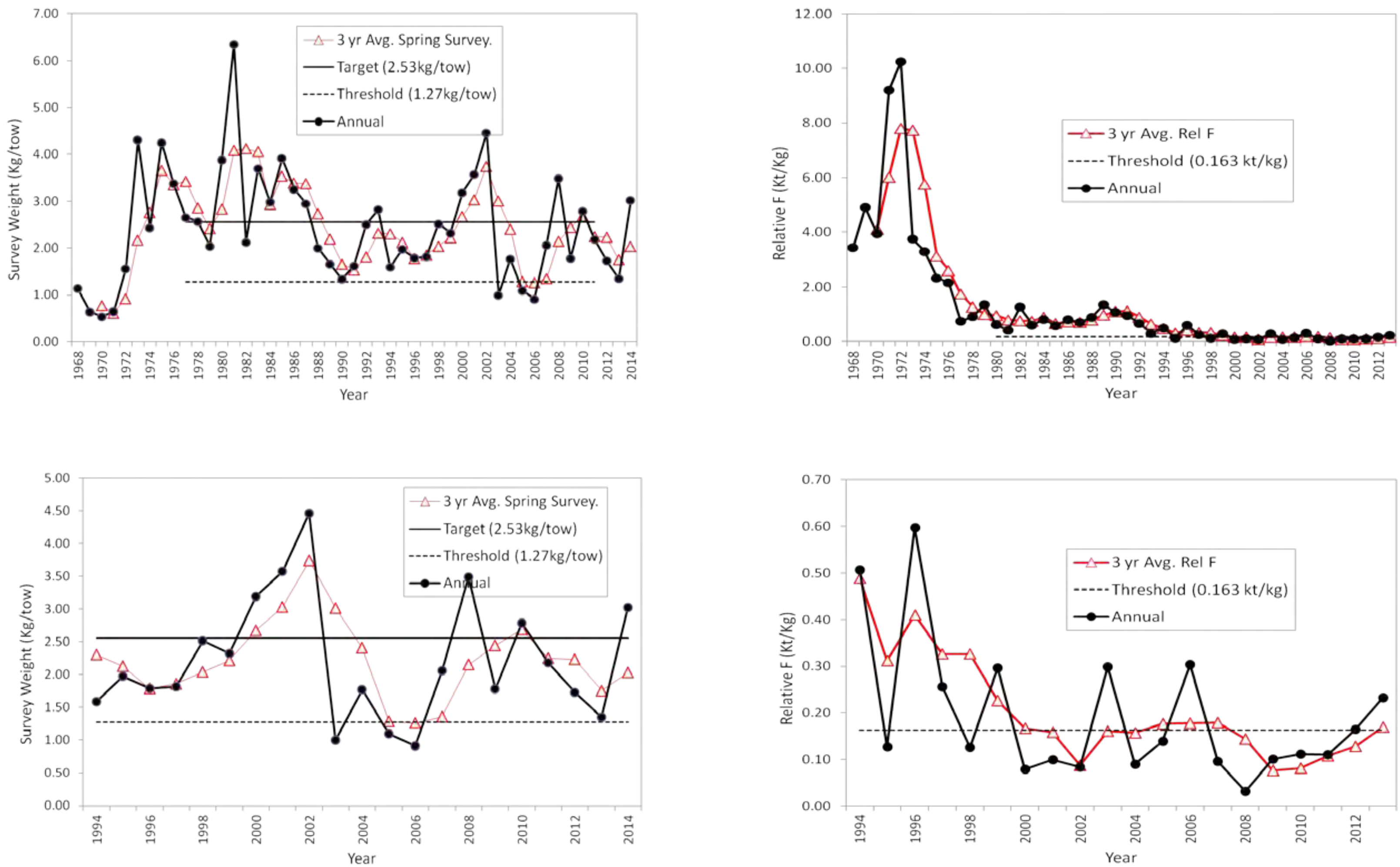

Figure 28 - ***Southern red hake*** spring survey biomass in kg/tow (LEFT) and relative exploitation ratios (RIGHT) of the total catch to the spring survey indices in kt/kg and associated 3-yr moving averages (red lines). The horizontal dash lines represent the biomass and overfishing thresholds and the solid line is the biomass target. The BOTTOM panels reflect the most recent 20 years of the entire time series

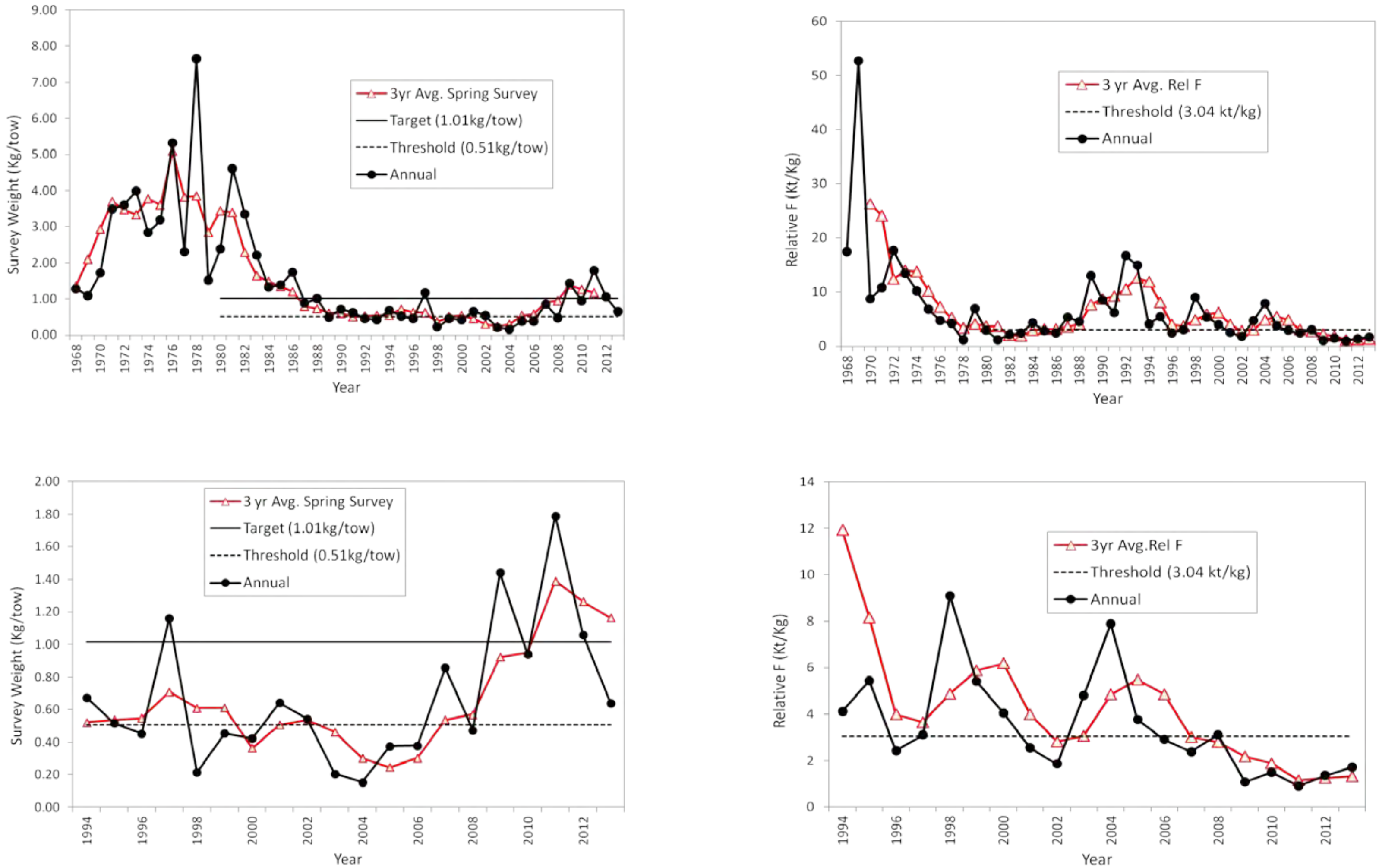

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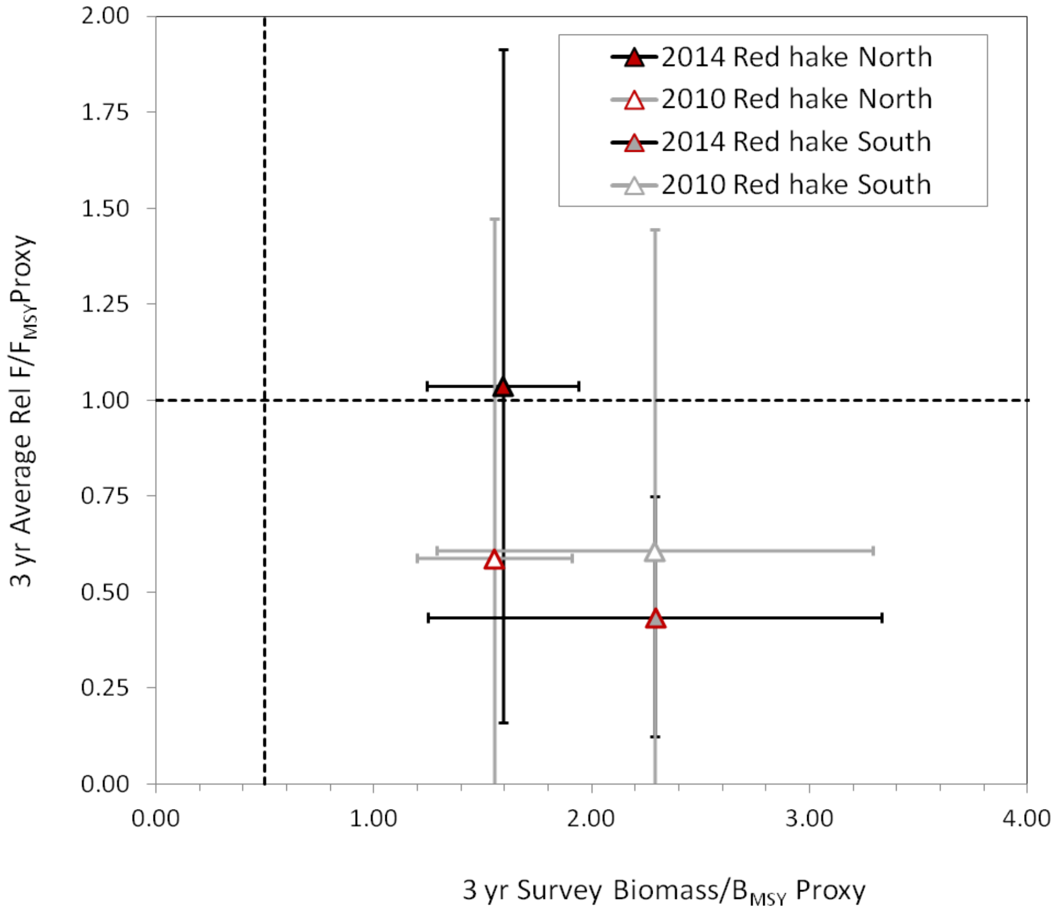
Figure 29 - Red hake biomass and fishing stock status plots for specification years 2012-2014 (labeled as 2010) and 2015-2017 (labeled as 2014) and associated 95% confidence intervals. The triangle and circle symbols are points estimates derived from the ratio of the most recent 3yr average index to 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 (2011-2013) while red hake used the 3-year average spring survey biomass (2012-2014 in the north and 2011-2013) from 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**) for years 2011-2013 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 result in overfishing." ABC's for specification years 2015-2017 were updated for each stock of red and silver hake. However, the 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 FMSY 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, with the 50th percentile being risk neutral. Described below are the current 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 47Table 48 and Figure 30Figure 31 based on the median value of the OFL distribution. The resulting OFL estimates for northern silver hake stock was 43,608 mt (95% Confidence interval of 10,000 – 248,000 mt) and 60,148 mt (95% Confidence interval of 12,000 – 336,000 mt) for the southern silver hake. Northern red hake OFL estimate was 331 mt (95% confidence interval of 77 – 543 mt) and 3,534 mt (95% confidence interval of 2,077 – 5,041 mt) for the southern red hake stock.

The recommended 2015-2017 ABC for red and silver hake are also provided in Table 47Table 48 and Figure 30Figure 31.

Silver hake 2015 – 2017 ABC set at 25th percentile to account for scientific uncertainty:

- 24,383 mt (53% of OFL; 1504% of 2013 catch) north
- 32,424 mt (54% of OFL; 598% of 2013 catch) southern whiting

Red hake 2015 – 2017 ABC set at 40th percentile to account for scientific uncertainty:

- 287 mt (89% of OFL; 92% of 2013 catch) north
- 3,179 mt (93% of OFL; 290% of 2013 catch) south

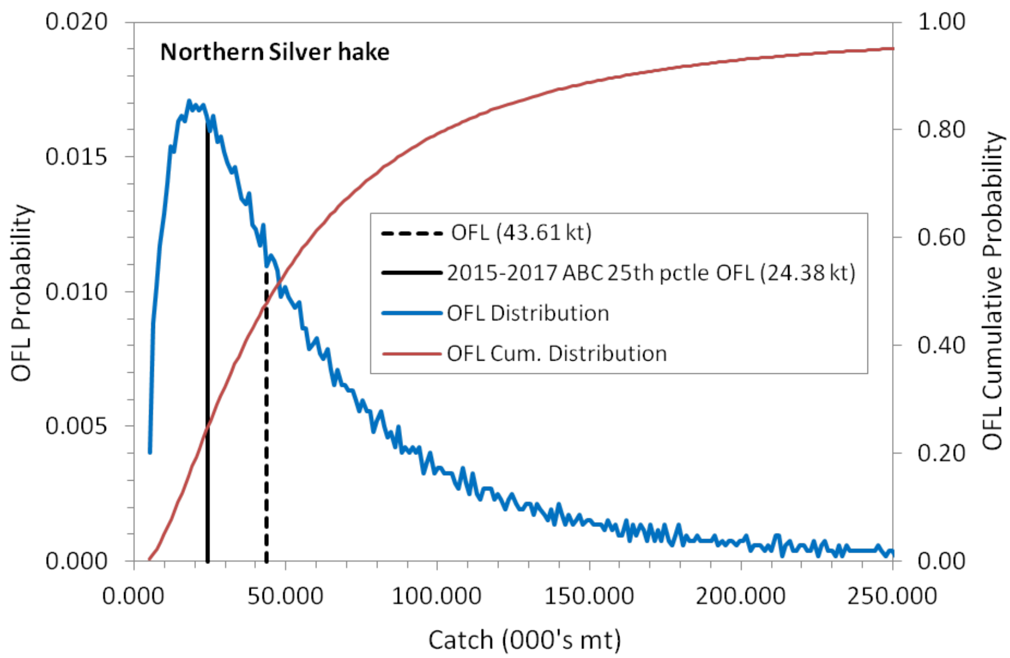
Table 47 - Summary stock status and Overfishing limit (OFL) for specification year 2015-2017 for both northern and southern ***silver hake*** stocks. Allowable Biological Catch (ABC) estimate, defined as the 25th percentile of OFL distribution and associated risk of exceeding FMSY proxy are provided.

	North	**South**
3-year Average Fall Index 2011-2013 (kg/tow)	15.72	1.70
BMSY Proxy Threshold (kg/tow)	3.21	0.83
Ratio of 3-year average Fall index (2011-2013) to BMSY Proxy	**4.90**	**2.05**
3-Year Average Relative Exploitation Index 2011-2013 (kt/kg)	0.14	3.86
FMSY Proxy 1973-1982 (kt/kg)	2.78	34.18
Ratio of 3-year average Exploitation index (2011-2013) to FMSY Proxy	**0.05**	**0.11**
OFL (000's mt) based on point estimate	43.61	60.15
ABC (000's mt) does not include 4% Adj for offshore hake	24.38	31.18
ABC/OFL	0.56	0.52
Pr (F > FMSY)	0%	0%

Table 48 - Summary stock status and Overfishing limit (OFL) for specification year 2015-2017 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 2012-2014 (kg/tow)	2.03	NA
3-year Average Spr. Index 2011-2013 (kg/tow)	NA	1.16
BMSY Proxy Threshold (kg/tow)	1.27	0.51
Biomass Stock Status - Ratio of recent 3-year average Spr. index to BMSY Proxy	**1.61**	**2.30**
3-Year Average Relative Exploitation Index 2011-2013 (kt/kg)	0.17	1.32
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	**1.04**	**0.43**
OFL (000's mt) based on point estimate	0.33	3.53
ABC (000's mt)	0.29	3.18
ABC/OFL	0.88	0.90
Pr (F > FMSY)	6%	29%

Figure 30 - 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.



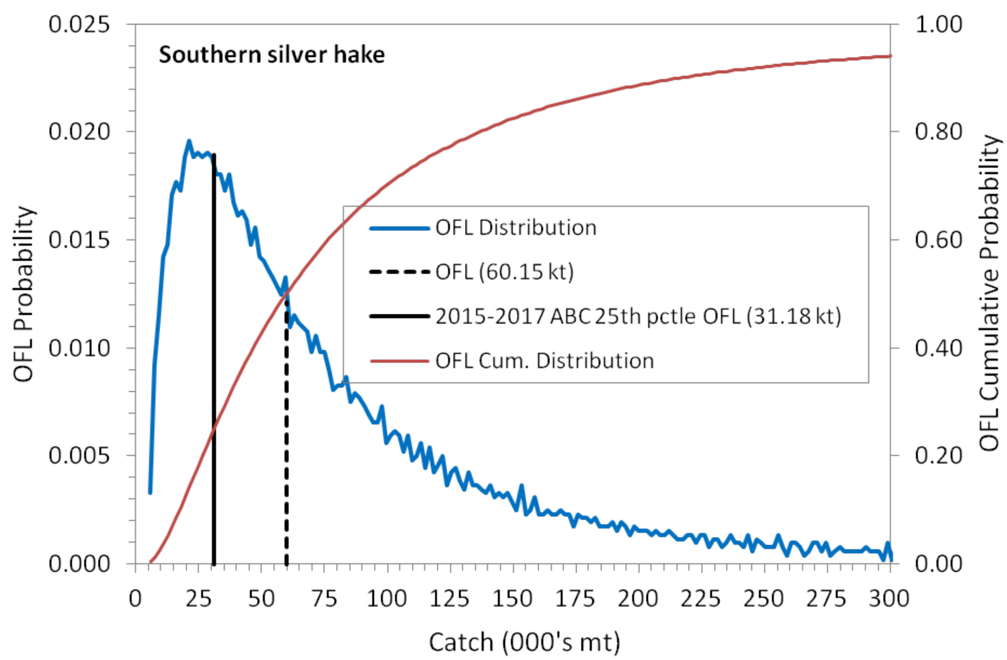
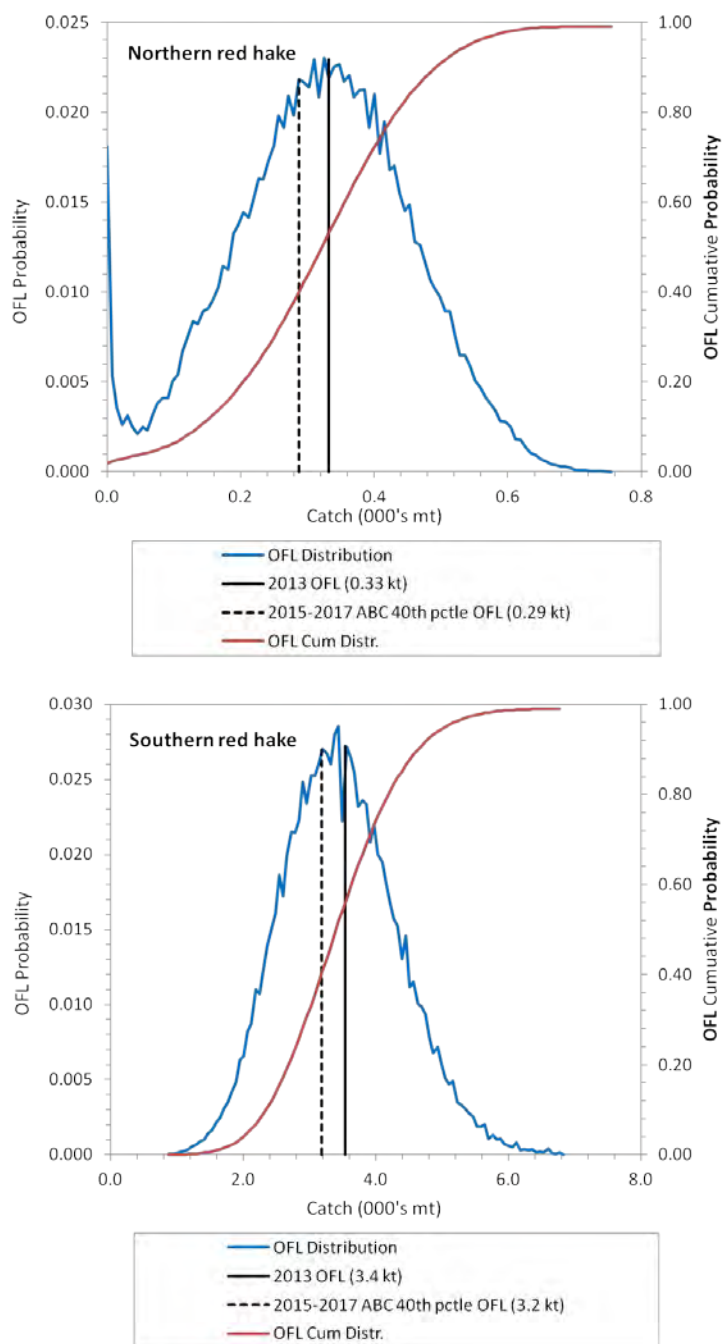


Figure 31 - 2014 OFL frequency distribution for the northern (TOP) and southern (BOTTOM) stock of red hake derived as a cross product of the fall survey and relative exploitation probability distributions. The spring survey probability distributions were derived from the most recent 3-yr mean and variance 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 2013 catches at the median of F_{MSY} for red and silver hake (Table 49-Table 52and Figure 32Figure 33). 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 (6%) and a moderate risk (29%) risk of exceeding the overfishing limit for the northern and southern stocks respectively at the proposed updated ABC levels.

Table 49 - Risk of exceeding F_{MSY} proxy over a range of catches (ABC and OFL estimate from the probability distribution in Bold) for ***northern silver hake*** stocks. 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	Catch (kt)	% of OFL_50th Pctile (45.87 kt)	% of 2013 Catch	Prob. (F > $FMSY_{Proxy}$)
5	9.96	22%	576%	0%
10	13.83	30%	799%	0%
20	20.85	45%	1205%	0%
25	**24.38**	**53%**	**1409%**	**0%**
30	28.05	61%	1621%	0%
40	36.19	79%	2092%	4%
45	40.79	89%	2358%	25%
50	**45.87**	**100%**	**2652%**	**68%**
60	58.33	127%	3372%	99%
70	75.43	164%	4360%	99%
80	102.58	224%	5929%	99%

Table 50 - Risk of exceeding F_{MSY} proxy over a range of catches (ABC and OFL estimate from the distribution in Bold) for and ***southern silver hake*** stocks. 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	Catch (kt)	% of OFL_50th Pctile (59.69 kt)	% of 2013 Catch	Prob. (F > $FMSY_{Proxy}$)
5	12.34	21%	215%	0%
10	17.39	29%	302%	0%
20	26.55	44%	462%	0%
25	**31.18**	52%	542%	**0%**
30	36.05	60%	627%	0%
40	46.81	78%	814%	4%
45	52.97	89%	921%	27%
50	**59.69**	100%	1038%	**56%**
60	76.23	128%	1326%	97%
70	99.47	167%	1730%	99%
80	136.27	228%	2370%	99%

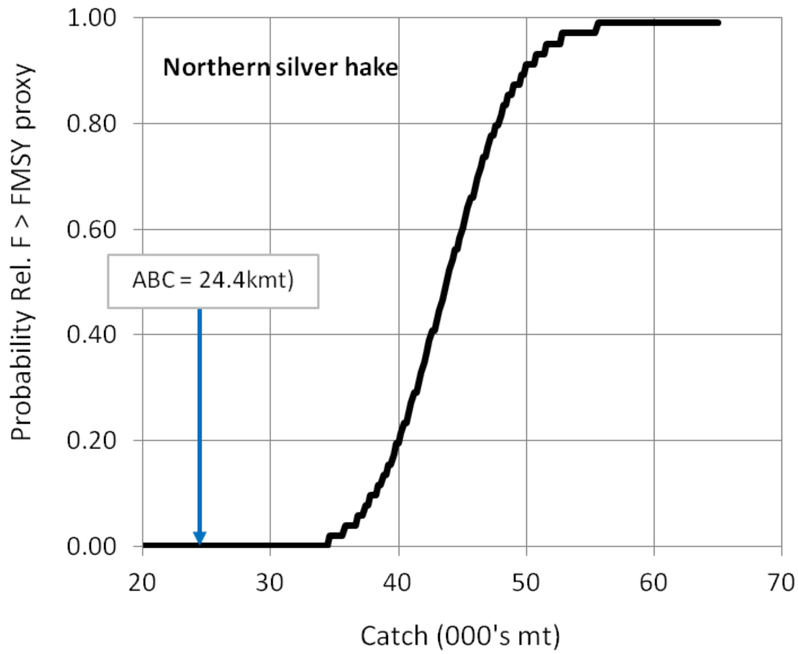
Table 51 - Risk of exceeding F_{MSY} proxy over a range of catches (ABC and OFL estimate from the probability distribution in Bold) for ***northern red hake*** stocks. Relative F probabilities were calculated from realizations of the three average fall survey distribution and the OFL estimate. ***Note 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	Catch (kt)	% of OFL_50th Pctile (0.322 kt)	% of 2013 Catch (0.364 kt)	Prob. (F > $FMSY_{Proxy}$)
5	0.077	24%	21%	0%
10	0.137	43%	38%	0%
20	0.204	63%	56%	0%
25	0.228	71%	63%	0%
30	0.250	78%	69%	0%
35	0.269	84%	74%	0%
40	**0.287**	**89%**	**79%**	**6%**
45	0.305	95%	84%	17%
50	**0.322**	**100%**	**88%**	**37%**
60	0.356	111%	98%	78%
70	0.392	122%	108%	95%
80	0.433	135%	119%	99%

Table 52 - Risk of exceeding F_{MSY} proxy over a range of catches (ABC and OFL estimate from the distribution in Bold) for and ***southern red hake*** stocks. 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	Catch (kt)	% of OFL_50th Pctile (3.40 kt)	% of 2013 Catch (1.10 kt)	Prob. (F > $FMSY_{Proxy}$)
5	2.08	61%	189%	0%
10	2.34	69%	213%	0%
20	2.68	79%	244%	10%
25	2.82	83%	257%	14%
30	2.95	87%	268%	17%
35	3.07	90%	279%	23%
40	**3.18**	**93%**	**289%**	**29%**
45	3.29	97%	299%	35%
50	**3.40**	**100%**	**309%**	**41%**
60	3.63	107%	330%	54%
70	3.88	114%	353%	68%
80	4.19	123%	381%	82%

Figure 32 - Probability of exceeding FMSY proxy for the northern (TOP) and southern (BOTTOM) ***silver hake*** stocks based on the updated 2014 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.



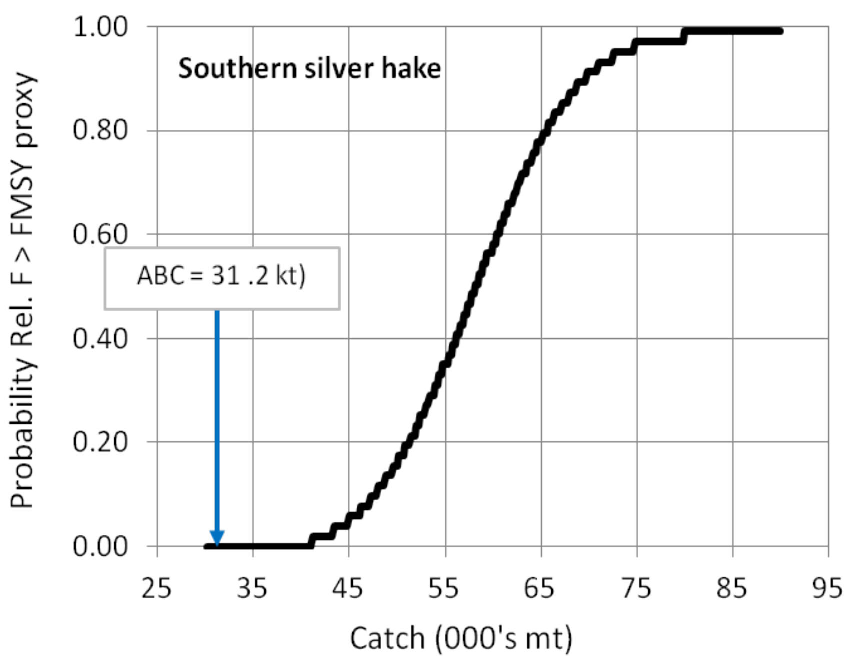
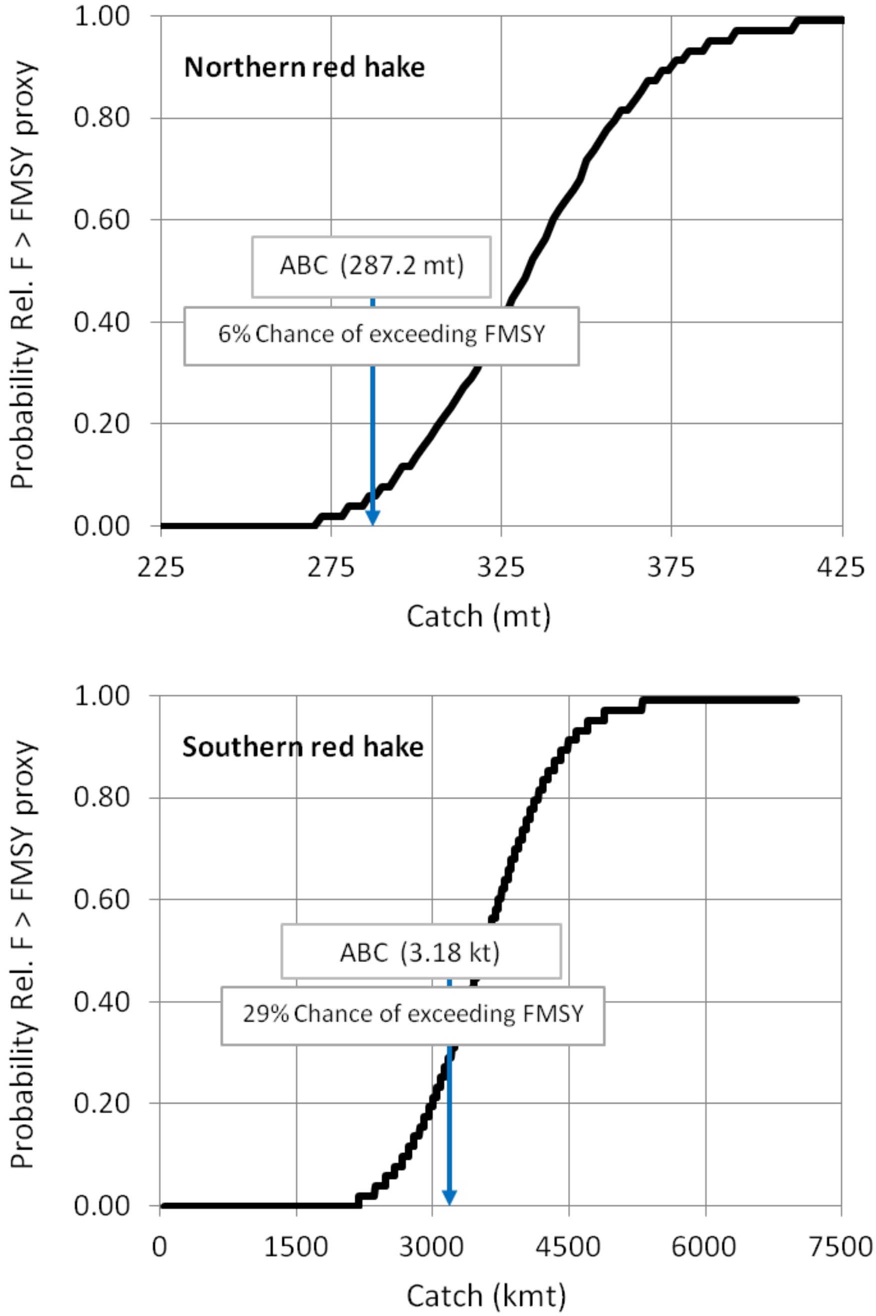


Figure 33 - Probability of exceeding FMSY proxy for the northern (TOP) and southern (BOTTOM) ***red hake*** stocks based on the updated 2014 OFL. The risk of overfishing is a product of the probability of Rel.F > FMSY proxy for each survey realizations and the survey probability distributions.



8.4 Summary

The updated stock assessment for the small multi-species groundfish was completed by adding catch and indices through 2014 to the previous 1955-2009 assessment to develop recommendations for the 2015-2017 ABC. Catch information consisted of commercial landings, discards and recreational catch for red hake. Catch data was combined with fisheries independent survey data from the fall and spring Northeast Fisheries Science Center 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 survey. Uncertainty in the Overfishing Limits was re-estimated to determine current ABC levels based on the current definition in Amendment 19.

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 (15.72kg/tow in the north vs 1.70kg/tow in the south) are both well above the overfished management threshold (3.21 kg/tow in the north vs 0.83kg/tow in the south), influenced by the recent observed increases in the fall survey trends. The exploitation index measured as the ratio of catch to survey has remained consistently low since the previous benchmark assessment and well below (0.14 kt/kg in the north vs 3.86 kt/kg in the south) the management overfishing definition thresholds (2.78 kt/kg in the north vs 34.17 kt/kg in the south). Conversely, the red hake assessment update indicates that both stocks are not overfished. However, overfishing is occurring in the northern stock while overfishing is not occurring in the southern stock of red hake. The recent three year arithmetic mean biomass index based on the NEFSC spring bottom trawl survey for the northern stock (2012-2014 = 2.03 kg/tow) and southern stock (2011-2013 = 2.42 kg/tow) were both above the proposed management threshold (1.27 kg/tow in the north vs 0.51 kg/tow in the south). The recent three year average exploitation index (0.170 kt/kg) was just above the management threshold in the north (0.163 kt/kg) and below (1.320 kt/kg) the management threshold in the south (3.038 kt/kg).

The proposed ABC recommendations for Silver hake 2015 – 2017 ABC set at 25th percentile to account for scientific uncertainty was estimated at 24,383 mt in the north and 31,177 mt in the south. Both ABC's were approximately above 50% of the OFL with zero risk of exceeding the overfishing limit. Red hake proposed ABC recommendations for 2015 – 2017 set at 40th percentile of the OFL resulted in 287 mt in the north (89% of OFL) and 3,179 mt in the south (93% of OFL), with a low (6%) and moderate (29%) risks of exceeding the overfishing limit in the north and the south respectively.

Stock status for both northern and southern stock of silver hake continues to improve with increasing trends in population biomass and relatively stable catches in the recent years. The proposed OFL estimates suggest that both stocks can withstand higher levels of catch with very little to no risk of exceeding the overfishing limit. 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. Although northern red hake population biomass increased in 2014, there has been a declining trend in survey estimates in prior years with 2013 survey estimate second lowest in the recent decade. This resulted in a change in overfishing status from being below reference threshold to slightly above the threshold. The proposed ABC for 2014 suggest a low risk of exceeding the overfishing limit, should the population biomass and catches remaining at the current level. Catches have been at or above ABC with poor recruitment in the last three years which may partly explain the lack of response to population growth. However, with the relatively strong incoming year class observed in 2014 and the assumption that current environmental and fishing conditions will prevail, there is potential for population growth in the subsequent years. It should be noted that It will be premature to assert with certainty, the faith of this incoming year class until subsequent years of observations are made from additional years of sampling.

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 a slight increase in the relative exploitation index but without a change in fishery and population status relative to the reference thresholds. Recruitment has been poor over the last two decades. Although the biomass threshold is above the target and threshold, the population biomass will likely continue to decline if recruitment remains poor at current catch levels.

9.0 Whiting PDT Membership

The Whiting Plan Development Team includes:

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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**).**

12.0 Assessment Tables

Table 53 - Summary of major regulatory measures for the Small Mesh Multispecies Fishery since 1987.

Year	Ammendment/ Framework Adj.	Brief Summary
1987	Amendment 1	Established area and seasonal restriction pertaining to small mesh fishing for silver and red hake went into effect
1991	Amendment 4	Mandatory reporting and sea sampling compliance. Defined and established the Cultivator Shoals Area mesh program. Set minimum Mesh restrictions for small mesh multispecies 2.5 inches. Goal to improve size selectivity and bycatch reduction fo regulated multispecies
1994	Framework Adj. 6	Increased minimum mesh size from 2.5 in to 3.0 Intend to reduce catch on Juve market
1995	Framework Adj. 9	Implementation of small mesh Areas I and II off the coast of New Hampshire
1999/2000	Amendment 12	Adjustment to fishing seasons to the cultivator Shoals Area Small mesh program. Established possession limits for vessels fishing outside cultivator Shoals Area. Gear regulation adjustment was implemented. allowances for transferring silver hake at sea (bait)
2000	Framework Adj. 35	Implementation of Raised Footrope Trawl off Cape Cod
2002	Modification to Framework Adj. 35	Adjusted the boundary along the eastern side of cape Cod and extended the season to Dec 31
2003	Framework Adj. 37	Streamed lined varying management measures to increase consistency between exemption areas
2003	Control Date	Implemented with intentions of developing a limited access program
2003	Framework Adj. 38	Established the Grate raised Footrope Exemption in the GOM area.
2012	Secretarial Amendment	Brought portions of the FMP into compliance with the Magnuson-Stevens Act requirements to (10 have ACL (2) measures to ensure accountability for each council managed fishery. The secretarial amendment was necessary because the mechanism through which the Council was intending to adopt Amendment 19 was delayed
2013	Amendment 19	Allowed Council to incorporate updated stock assessment information and adopt the ACL structure implemented in the secretarial amendment. Modification to accountability measures and adoption of new biological reference points and trip limit for red hake was established.
2013	Framework Adjustment 50	Established a separate sub-ACL of GB yellowtail flounder for the small mesh fishery (whiting and squid fishery)
2014	Framework Adjustment 51	Implemented accountability measures for sub-ACL

Table 54 - Summary of Current possession limits for silver, red and offshore hake.

Exemption Area	**Codend Mesh Size**	**Silver and offshore hake combined, possession limit (lbs)**	**Red hake possession limit (lbs)**
Gulf of Maine Raised foot Rope)	Mesh < 2.5"	7,500	5,000
Cultivator Shoals	Mesh >= 3.0"	30,000	5,000
Area I & II	Mesh < 2.5"	3,500	5,000
	2.5" < Mesh < 3.0"	7,500	
	mesh >= 3.0"	30,000	
Cape Cod Raised Foot Rope	2.5" < Mesh < 3.0"	7,500	5,000
	mesh >= 3.0"	30,000	
SNE and MA	Mesh < 2.5"	3,500	5,000
	2.5" < Mesh < 3.0"	7,500	
	mesh >= 3.0"	40,000	

Table 55 - Estimate of total catch (landings and discards) in metric tons for both northern and southern silver hake. Southern estimates are derived using survey length-based proportions of silver and offshore hake. Catch estimates (in bold) from 2011 through 2013 were used in this assessment update.

	Northern Stock					Southern Stock				
Year	Domestic Landings (000's mt)	Foreign Landings (000's mt)	Discards (000's mt)	Total (000's mt)	% Discards	Domestic Landings (000's mt)	Foreign Landings (000's mt)	Discards (000's mt)	Total (000's mt)	% Discards
1955	53.360			53.360		13.260			13.260	
1956	42.150			42.150		14.240			14.240	
1957	62.750			62.750		16.430			16.430	
1958	49.900			49.900		12.900			12.900	
1959	50.610			50.610		16.390			16.390	
1960	45.540			45.540		8.820			8.820	
1961	39.690			39.690		12.650			12.650	
1962	42.430	36.575		79.005		17.940	41.900		59.840	
1963	36.400	37.525		73.925		89.430	111.548		200.978	
1964	37.220	57.240		94.460		147.050	184.276		331.326	
1965	29.510	15.793		45.303		294.120	299.159		593.279	
1966	33.570	14.239		47.809		202.320	214.297		416.617	
1967	26.490	6.882		33.372		87.380	88.631		176.011	
1968	30.870	10.506		41.376		58.160	59.928		118.088	
1969	16.010	8.047		24.057		74.890	75.443		150.333	
1970	15.220	12.305		27.525		26.830	32.938		59.768	
1971	11.160	25.243		36.403		70.510	91.587		162.097	
1972	6.440	18.784		25.224		88.180	107.165		195.345	
1973	14.010	18.086		32.096		102.080	116.075		218.155	
1974	6.910	13.775		20.685		102.400	115.887		218.287	
1975	12.570	27.308		39.878		72.160	93.120		165.280	
1976	13.480	0.151		13.631		64.610	58.458		123.068	
1977	12.460	0.002		12.462		57.160	47.852		105.012	
1978	12.610			12.610		25.830	14.353		40.183	
1979	3.420			3.420		16.400	4.877		21.277	
1980	4.730			4.730		11.680	1.698		13.378	
1981	4.420		2.640	7.060	37%	13.430	3.043	3.500	19.973	18%
1982	4.660		2.910	7.570	38%	14.150	2.397	4.650	21.197	22%
1983	5.310		2.640	7.950	33%	11.860	0.620	4.810	17.290	28%
1984	8.290		2.590	10.880	24%	12.960	0.412	4.880	18.252	27%
1985	8.300		2.560	10.860	24%	12.820	1.321	3.870	18.011	21%
1986	8.500		2.350	10.850	22%	9.700	0.550	4.330	14.580	30%
1987	5.660		2.110	7.770	27%	9.550	0.002	4.250	13.802	31%
1988	6.790		1.790	8.580	21%	8.950		4.500	13.450	33%
1989	4.650		2.320	6.970	33%	13.000		6.570	19.570	34%
1990	6.380		1.960	8.340	24%	13.020		5.970	18.990	31%
1991	6.060		1.260	7.320	17%	9.740		3.080	12.820	24%
1992	5.310		1.420	6.730	21%	10.530		3.450	13.980	25%
1993	4.360		0.690	5.050	14%	12.490		5.170	17.660	29%
1994	3.900		0.240	4.140	6%	12.180		5.940	18.120	33%
1995	2.590		0.630	3.220	20%	11.990		1.400	13.390	10%
1996	3.620		0.820	4.440	18%	12.130		0.480	12.610	4%
1997	2.800		0.240	3.040	8%	12.550		0.620	13.170	5%
1998	2.050		0.690	2.740	25%	12.560		0.530	13.090	4%
1999	3.440		0.740	4.180	18%	10.420		3.550	13.970	25%
2000	2.590		0.360	2.950	12%	9.470		0.330	9.800	3%
2001	3.390		0.480	3.870	12%	8.880		0.190	9.070	2%
2002	2.590		0.510	3.100	16%	4.890		0.410	5.300	8%
2003	1.810		0.200	2.010	10%	6.280		0.600	6.880	9%
2004	1.050		0.120	1.170	10%	6.970		1.200	8.170	15%
2005	0.830		0.060	0.890	7%	6.400		1.580	7.980	20%
2006	0.900		0.040	0.940	4%	4.580		0.160	4.740	3%
2007	1.010		0.750	1.760	43%	5.070		0.150	5.220	3%
2008	0.620		0.170	0.790	22%	5.580		1.030	6.610	16%
2009	1.040		0.190	1.230	15%	6.750		0.840	7.590	11%
2010	1.690		0.790	2.480	32%	6.390		0.780	7.170	11%
2011	**1.920**		**0.120**	**2.040**	**6%**	**5.750**		**1.810**	**7.560**	**24%**
2012	**1.940**		**0.290**	**2.230**	**13%**	**5.430**		**1.020**	**6.450**	**16%**
2013	**1.370**		**0.250**	**1.620**	**15%**	**4.790**		**0.640**	**5.430**	**12%**

Table 56 - Estimate of total catch (landings and discards) in metric tons for both northern and southern red hake. Catch estimates (in bold) from 2011 through 2013 were used in this assessment update.

	Northern Stock						Southern Stock					
Year	Domestic Landings (000's mt)	Foreign Landings (000's mt)	Recreational Catch (000's mt)	Discards (000's mt)	Total Catch (000's mt)	% Discards	Domestic Landings (000's mt)	Foreign Landings (000's mt)	Recreational Catch (000's mt)	Discards (000's mt)	Total Catch (000's mt)	% Discards
1960	3.792				3.792		4.286				4.286	
1961	3.276				3.276		8.105				8.105	
1962	1.911		0.010	1.600	3.521		11.865		0.890	4.000	16.755	
1963	1.225	2.056	0.000	1.600	4.881		29.712	2.189	0.770	4.000	36.671	
1964	0.288	1.121	0.000	1.700	3.109		32.622	10.751	0.850	3.760	47.983	
1965	0.200	2.573	0.000	1.620	4.393		25.246	67.744	0.630	4.290	97.910	
1966	0.885	4.690	0.000	1.600	7.175		3.985	103.937	0.090	3.770	111.782	
1967	0.577	1.286	0.000	1.400	3.263		6.764	52.019	0.170	3.660	62.613	
1968	0.552	2.075	0.000	1.300	3.927		7.001	11.137	0.580	3.720	22.438	
1969	0.146	1.875	0.000	1.120	3.141		5.539	47.389	0.490	3.620	57.038	
1970	0.261	0.771	0.000	1.100	2.132		4.679	6.775	0.410	3.140	15.004	
1971	0.377	4.428	0.000	1.160	5.965		3.227	31.907	0.290	2.310	37.734	
1972	0.538	14.488	0.000	0.960	15.986		1.995	59.199	0.180	2.100	63.474	
1973	0.362	14.926	0.000	0.910	16.198		3.603	47.759	0.320	2.240	53.922	
1974	0.891	6.332	0.000	0.820	8.043		2.183	24.460	0.190	2.160	28.993	
1975	0.450	8.251	0.000	1.200	9.901		2.065	17.911	0.050	1.760	21.786	
1976	0.653	5.684	0.000	0.930	7.267		3.905	18.560	0.650	1.830	24.945	
1977	0.889	0.002	0.000	1.080	1.971		2.522	4.540	0.750	1.820	9.632	
1978	1.223		0.000	1.120	2.343		3.327	2.136	0.970	2.440	8.873	
1979	1.523		0.010	1.220	2.753		6.624	0.968	0.250	2.670	10.512	
1980	1.029		0.000	1.370	2.399		3.927	0.155	0.140	2.700	6.922	
1981	1.246		0.030	1.320	2.596	51%	2.124	0.196	0.180	2.720	5.220	52%
1982	1.210		0.000	1.460	2.670	55%	2.993	0.177	0.030	3.780	6.980	54%
1983	0.895		0.000	1.350	2.245	60%	1.334	0.107	0.140	3.890	5.471	71%
1984	1.059		0.000	1.330	2.389	56%	1.214	0.057	0.550	3.910	5.731	68%
1985	0.992		0.000	1.270	2.262	56%	0.827	0.076	0.030	2.970	3.903	76%
1986	1.457		0.000	1.190	2.647	45%	0.644	0.050	0.210	3.390	4.294	79%
1987	1.013		0.000	1.050	2.063	51%	0.943		0.470	3.310	4.723	70%
1988	0.862		0.000	0.900	1.762	51%	0.871		0.250	3.460	4.581	76%
1989	0.776		0.000	1.450	2.226	65%	0.931		0.440	5.010	6.381	79%
1990	0.826		0.000	0.600	1.426	42%	0.798		0.510	4.750	6.058	78%
1991	0.743		0.000	0.820	1.563	52%	0.925		0.290	2.610	3.825	68%
1992	0.918		0.000	0.730	1.648	44%	1.245		0.190	6.340	7.775	82%
1993	0.768		0.000	0.080	0.848	9%	0.924		0.090	5.310	6.324	84%
1994	0.727		0.000	0.080	0.807	10%	0.983		0.070	1.720	2.773	62%
1995	0.186		0.000	0.060	0.246	24%	1.428		0.050	1.330	2.808	47%
1996	0.409		0.010	0.660	1.079	61%	0.700		0.020	0.380	1.100	35%
1997	0.338		0.000	0.130	0.468	28%	0.999		0.170	2.420	3.589	67%
1998	0.187		0.000	0.130	0.317	41%	1.154		0.050	0.740	1.944	38%
1999	0.220		0.000	0.470	0.690	68%	1.351		0.050	1.060	2.461	43%
2000	0.197		0.000	0.060	0.257	23%	1.417		0.040	0.250	1.707	15%
2001	0.222		0.000	0.140	0.362	39%	1.469		0.020	0.140	1.629	9%
2002	0.275		0.000	0.100	0.375	27%	0.663		0.010	0.330	1.003	33%
2003	0.210		0.000	0.090	0.300	30%	0.623		0.020	0.350	0.993	35%
2004	0.103		0.000	0.060	0.163	37%	0.588		0.010	0.620	1.218	51%
2005	0.096		0.000	0.060	0.156	38%	0.356		0.060	1.010	1.426	71%
2006	0.096		0.000	0.180	0.276	65%	0.375		0.050	0.670	1.095	61%
2007	0.069		0.000	0.130	0.199	65%	0.470		0.020	1.550	2.040	76%
2008	0.052		0.000	0.060	0.112	54%	0.580		0.070	0.810	1.460	55%
2009	0.085		0.000	0.100	0.185	54%	0.575		0.100	0.870	1.545	56%
2010	0.067		0.000	0.240	0.307	78%	0.578		0.090	0.740	1.408	53%
2011	**0.139**		**0.001**	**0.100**	**0.240**	**42%**	**0.495**		**0.115**	**1.010**	**1.620**	**62%**
2012	**0.097**		**0.000**	**0.190**	**0.287**	**66%**	**0.751**		**0.037**	**0.650**	**1.438**	**45%**
2013	**0.095**		**0.002**	**0.220**	**0.317**	**69%**	**0.439**		**0.076**	**0.580**	**1.095**	**53%**

Table 57 - Northern silver hake estimated commercial landings in metric tons (TOP) and percent (BOTTOM) by major gear groupings from 1994-2013.

Year	Trawl	Scallop Dredge	Other	Total
1994	3744	0	154	3898
1995	2293		320	2613
1996	3562		58	3620
1997	2730		72	2802
1998	2007	0	38	2045
1999	3407		40	3446
2000	2477		114	2591
2001	3300	9	89	3398
2002	2565	0	31	2596
2003	1753	3	52	1808
2004	970		80	1049
2005	725	2	92	819
2006	883	2	19	904
2007	978	0	9	987
2008	543		37	580
2009	949		61	1010
2010	1643	1	49	1694
2011	1846		72	1918
2012	1871	1	67	1939
2013	1305		66	1372

Year	Trawl	Scallop Dredge	Other	Total
1994	96%	0%	4%	100%
1995	88%	0%	12%	100%
1996	98%	0%	2%	100%
1997	97%	0%	3%	100%
1998	98%	0%	2%	100%
1999	99%	0%	1%	100%
2000	96%	0%	4%	100%
2001	97%	0%	3%	100%
2002	99%	0%	1%	100%
2003	97%	0%	3%	100%
2004	92%	0%	8%	100%
2005	89%	0%	11%	100%
2006	98%	0%	2%	100%
2007	99%	0%	1%	100%
2008	94%	0%	6%	100%
2009	94%	0%	6%	100%
2010	97%	0%	3%	100%
2011	96%	0%	4%	100%
2012	96%	0%	3%	100%
2013	95%	0%	5%	100%

Table 58 - Southern silver hake estimated commercial landings in metric tons (TOP) and percent (BOTTOM) by major gear groupings from 1994-2013.

Year	Trawl	Scallop Dredge	Other	Total
1994	11288		871	12159
1995	10695	0	1367	12062
1996	12549		10	12559
1997	12744		17	12761
1998	12810	0	18	12828
1999	10566	0	9	10575
2000	9724		10	9734
2001	9365	1	6	9372
2002	5327		13	5340
2003	6816		17	6833
2004	7146		291	7436
2005	6212	11	448	6671
2006	4274	23	332	4629
2007	5186	67	119	5372
2008	5099	0	575	5673
2009	6260	21	469	6750
2010	6239	3	144	6385
2011	5786	1	43	5831
2012	5423	0	38	5461
2013	4794	0	18	4812

Year	Trawl	Scallop Dredge	Other	Total
1994	93%	0%	7%	100%
1995	89%	0%	11%	100%
1996	100%	0%	0%	100%
1997	100%	0%	0%	100%
1998	100%	0%	0%	100%
1999	100%	0%	0%	100%
2000	100%	0%	0%	100%
2001	100%	0%	0%	100%
2002	100%	0%	0%	100%
2003	100%	0%	0%	100%
2004	96%	0%	4%	100%
2005	93%	0%	7%	100%
2006	92%	0%	7%	100%
2007	97%	1%	2%	100%
2008	90%	0%	10%	100%
2009	93%	0%	7%	100%
2010	98%	0%	2%	100%
2011	99%	0%	1%	100%
2012	99%	0%	1%	100%
2013	100%	0%	0%	100%

Table 59 - Northern red hake estimated commercial landings in metric tons (TOP) and percent (BOTTOM) by major gear groupings from 1994-2013.

Year	Trawl	Scallop Dredge	Other	Total
1994	681		37	718
1995	160		15	175
1996	390		4	394
1997	308		14	322
1998	170		3	173
1999	200		6	206
2000	165		6	172
2001	191	2	12	205
2002	242		3	245
2003	180		5	185
2004	73		10	83
2005	70	0	3	73
2006	77	0	0	77
2007	40	0	0	40
2008	7		0	7
2009	34		0	34
2010	51	0	0	51
2011	99		0	99
2012	77		0	77
2013	78		1	79

Year	Trawl	Scallop Dredge	Other	Total
1994	95%	0%	5%	100%
1995	91%	0%	9%	100%
1996	99%	0%	1%	100%
1997	96%	0%	4%	100%
1998	98%	0%	2%	100%
1999	97%	0%	3%	100%
2000	96%	0%	4%	100%
2001	93%	1%	6%	100%
2002	99%	0%	1%	100%
2003	97%	0%	3%	100%
2004	87%	0%	13%	100%
2005	96%	0%	4%	100%
2006	100%	0%	0%	100%
2007	100%	0%	0%	100%
2008	98%	0%	2%	100%
2009	100%	0%	0%	100%
2010	100%	0%	0%	100%
2011	100%	0%	0%	100%
2012	100%	0%	0%	100%
2013	99%	0%	1%	100%

Table 60 - Southern red hake estimated commercial landings in metric tons (TOP) and percent (BOTTOM) by major gear groupings from 1994-2013.

Year	Trawl	Scallop Dredge	Other	Total
1994	851		132	983
1995	987	0	436	1423
1996	694		5	700
1997	982		17	999
1998	1142		12	1154
1999	1337		14	1351
2000	1398		17	1415
2001	1437	0	26	1463
2002	653		10	663
2003	619		3	623
2004	568	0	19	587
2005	340	1	15	356
2006	363	2	11	375
2007	453	6	12	472
2008	477	0	102	580
2009	531	1	48	579
2010	528	0	24	553
2011	476	0	19	495
2012	722	0	28	751
2013	421	0	17	439

Year	Trawl	Scallop Dredge	Other	Total
1994	87%	0%	13%	100%
1995	69%	0%	31%	100%
1996	99%	0%	1%	100%
1997	98%	0%	2%	100%
1998	99%	0%	1%	100%
1999	99%	0%	1%	100%
2000	99%	0%	1%	100%
2001	98%	0%	2%	100%
2002	99%	0%	1%	100%
2003	99%	0%	1%	100%
2004	97%	0%	3%	100%
2005	96%	0%	4%	100%
2006	97%	0%	3%	100%
2007	96%	1%	3%	100%
2008	82%	0%	18%	100%
2009	92%	0%	8%	100%
2010	96%	0%	4%	100%
2011	96%	0%	4%	100%
2012	96%	0%	4%	100%
2013	96%	0%	4%	100%

Table 61 - Northern and southern red hake total recreational catch (mt) from 2004 – 2013, derived from the Marine Recreation Information Program (MRIP).

Year	North	South
2004	0.004	5.892
2005	0.001	53.879
2006	0.156	92.783
2007	0.143	18.863
2008	0.321	92.994
2009	1.189	107.801
2010	0.517	90.063
2011	0.682	115.207
2012	0.458	37.080
2013	2.394	75.723

Table 62 - Northern silver hake estimated commercial discards in metric tons (TOP) and percent (BOTTOM) by major gear groupings.

Year	Trawl_large mesh	Trawl small mesh	Shrimp trawl	Scallop Dredge	Sink Gillnet	Longline	Total
1989	297.30	1188.33	771.71	0.00	34.35	0.00	2291.68
1990	681.51	857.32	550.96	0.00	87.64	0.00	2177.44
1991	391.55	486.51	294.21	0.00	43.75	0.00	1216.01
1992	371.60	583.05	427.10	5.19	42.41	0.00	1429.34
1993	1616.55	180.48	170.63	59.72	60.40	0.00	2087.78
1994	44.55	0.00	83.80	1.49	43.76	0.00	173.61
1995	115.83	22.89	456.12	6.15	29.08	0.00	630.08
1996	64.41	20.24	681.30	2.26	56.50	0.00	824.71
1997	56.68	1.98	126.35	7.03	27.42	0.00	219.45
1998	126.16	0.00	0.00	35.14	9.03	0.00	170.33
1999	166.15	395.59	0.00	11.10	18.10	0.00	590.94
2000	185.95	1.06	0.00	2.65	24.34	0.00	214.00
2001	401.92	17.69	39.42	1.73	12.52	0.00	473.29
2002	379.93	102.66	0.00	1.16	9.10	0.00	492.86
2003	75.20	90.58	22.05	2.50	10.12	0.00	200.46
2004	66.26	29.24	13.39	0.14	2.92	0.00	111.95
2005	40.11	9.20	10.25	1.44	0.99	0.02	62.01
2006	20.94	4.97	9.81	0.63	1.13	0.00	37.48
2007	19.34	640.11	11.83	1.63	1.46	0.00	674.38
2008	48.18	58.72	48.36	0.21	6.25	0.00	161.73
2009	67.14	135.19	49.28	4.50	6.72	0.00	262.83
2010	59.04	402.01	218.80	0.74	5.22	0.01	685.82
2011	70.02	34.06	0.00	8.91	4.66	0.01	117.65
2012	107.10	38.72	129.90	6.70	11.32	0.05	293.78
2013	158.43	37.96	33.15	10.47	6.38	0.00	246.39

Year	Trawl_large mesh	Trawl small mesh	Shrimp trawl	Scallop Dredge	Sink Gillnet	Longline	Total
1989	13%	52%	34%	0%	1%	0%	100%
1990	31%	39%	25%	0%	4%	0%	100%
1991	32%	40%	24%	0%	4%	0%	100%
1992	26%	41%	30%	0%	3%	0%	100%
1993	77%	9%	8%	3%	3%	0%	100%
1994	26%	0%	48%	1%	25%	0%	100%
1995	18%	4%	72%	1%	5%	0%	100%
1996	8%	2%	83%	0%	7%	0%	100%
1997	26%	1%	58%	3%	12%	0%	100%
1998	74%	0%	0%	21%	5%	0%	100%
1999	28%	67%	0%	2%	3%	0%	100%
2000	87%	0%	0%	1%	11%	0%	100%
2001	85%	4%	8%	0%	3%	0%	100%
2002	77%	21%	0%	0%	2%	0%	100%
2003	38%	45%	11%	1%	5%	0%	100%
2004	59%	26%	12%	0%	3%	0%	100%
2005	65%	15%	17%	2%	2%	0%	100%
2006	56%	13%	26%	2%	3%	0%	100%
2007	3%	95%	2%	0%	0%	0%	100%
2008	30%	36%	30%	0%	4%	0%	100%
2009	26%	51%	19%	2%	3%	0%	100%
2010	9%	59%	32%	0%	1%	0%	100%
2011	60%	29%	0%	8%	4%	0%	100%
2012	36%	13%	44%	2%	4%	0%	100%
2013	64%	15%	13%	4%	3%	0%	100%

Table 63 - Southern silver hake estimated commercial discards in metric tons (TOP) and percent (BOTTOM) by major gear groupings.

Year	Trawl_large mesh	Trawl small mesh	Scallop Dredge	Sink Gillnet	Longline	Total
1989	680.37	6389.56	0.00	0.00	0.00	7069.93
1990	2743.07	3172.70	0.00	0.00	0.00	5915.77
1991	1191.65	2020.27	5.72	0.09	0.00	3217.73
1992	654.51	2771.14	17.16	3.30	0.00	3446.11
1993	5959.62	4081.28	354.54	4.76	0.00	10400.20
1994	594.14	3984.24	27.35	0.69	0.00	4606.42
1995	161.89	1175.51	125.60	0.45	0.00	1463.45
1996	40.51	431.60	32.37	0.19	0.00	504.67
1997	1818.14	219.41	31.12	2.06	0.00	2070.72
1998	6327.50	237.05	49.34	0.45	0.00	6614.33
1999	1111.53	1156.22	27.21	0.89	0.00	2295.85
2000	4959.45	154.48	68.21	7.62	0.00	5189.75
2001	36.43	176.83	11.80	0.00	0.00	225.06
2002	172.54	259.56	14.00	0.44	0.00	446.53
2003	19.91	582.01	4.11	1.28	0.00	607.31
2004	579.41	1027.09	11.34	0.37	0.00	1618.21
2005	138.62	1476.13	8.11	0.24	0.00	1623.10
2006	52.46	133.58	7.44	0.01	0.07	193.56
2007	31.04	178.24	6.88	0.00	0.00	216.16
2008	88.00	751.36	6.65	0.03	0.58	846.60
2009	69.01	812.78	22.00	0.16	0.00	903.95
2010	73.97	742.39	17.45	0.30	0.00	834.11
2011	39.67	1723.98	54.91	0.67	0.00	1819.23
2012	21.13	985.00	12.05	0.28	0.00	1018.45
2013	23.08	589.89	20.02	0.20	0.00	633.20

Year	Trawl_large mesh	Trawl small mesh	Scallop Dredge	Sink Gillnet	Longline	Total
1989	10%	90%	0%	0%	0%	100%
1990	46%	54%	0%	0%	0%	100%
1991	37%	63%	0%	0%	0%	100%
1992	19%	80%	0%	0%	0%	100%
1993	57%	39%	3%	0%	0%	100%
1994	13%	86%	1%	0%	0%	100%
1995	11%	80%	9%	0%	0%	100%
1996	8%	86%	6%	0%	0%	100%
1997	88%	11%	2%	0%	0%	100%
1998	96%	4%	1%	0%	0%	100%
1999	48%	50%	1%	0%	0%	100%
2000	96%	3%	1%	0%	0%	100%
2001	16%	79%	5%	0%	0%	100%
2002	39%	58%	3%	0%	0%	100%
2003	3%	96%	1%	0%	0%	100%
2004	36%	63%	1%	0%	0%	100%
2005	9%	91%	0%	0%	0%	100%
2006	27%	69%	4%	0%	0%	100%
2007	14%	82%	3%	0%	0%	100%
2008	10%	89%	1%	0%	0%	100%
2009	8%	90%	2%	0%	0%	100%
2010	9%	89%	2%	0%	0%	100%
2011	2%	95%	3%	0%	0%	100%
2012	2%	97%	1%	0%	0%	100%
2013	4%	93%	3%	0%	0%	100%

Table 64 - Northern red hake estimated commercial discards in metric tons (TOP) and percent (BOTTOM) by major gear groupings.

Year	Trawl_large mesh	Trawl small mesh	Shrimp trawl	Scallop Dredge	Sink Gillnet	Longline	Total
1989	394.95	692.05	329.90	0.00	4.86	0.00	1421.75
1990	144.86	304.94	314.48	0.00	4.63	0.00	768.91
1991	222.03	309.40	212.53	0.00	3.91	17.93	765.80
1992	147.84	486.92	87.56	2.39	0.88	0.36	725.94
1993	493.83	42.10	4.60	24.50	0.80	0.00	565.83
1994	8.84	0.00	7.50	2.19	3.84	0.00	22.38
1995	15.28	22.91	10.66	0.79	1.61	0.00	51.26
1996	11.78	508.40	105.80	2.98	3.71	0.00	632.67
1997	14.41	0.49	84.81	5.71	1.06	0.00	106.47
1998	1.14	0.00	0.00	0.14	1.45	0.00	2.73
1999	308.70	128.45	0.00	2.28	2.82	0.00	442.24
2000	27.89	0.40	0.00	4.06	3.65	0.00	36.01
2001	47.45	65.29	0.66	2.71	11.74	0.00	127.84
2002	30.86	53.47	0.00	2.12	3.21	0.51	90.17
2003	30.14	27.78	0.36	16.12	2.24	0.00	76.63
2004	26.42	25.27	0.79	0.84	1.81	1.67	56.80
2005	35.73	10.79	0.17	14.71	0.53	2.93	64.86
2006	41.41	125.14	3.33	1.39	8.83	1.54	181.64
2007	21.80	69.48	5.99	14.80	0.10	0.92	113.11
2008	36.11	15.14	1.59	0.35	2.59	2.13	57.91
2009	43.26	63.56	1.42	2.95	1.04	0.66	112.89
2010	33.69	153.99	3.96	10.04	1.25	5.72	208.65
2011	34.40	43.92	1.82	18.11	1.78	0.84	100.87
2012	56.37	113.55	6.16	9.43	1.69	0.91	188.12
2013	59.82	140.88	0.29	13.47	1.22	0.08	215.75

Year	Trawl_large mesh	Trawl small mesh	Shrimp trawl	Scallop Dredge	Sink Gillnet	Longline	Total
1989	28%	49%	23%	0%	0%	0%	100%
1990	19%	40%	41%	0%	1%	0%	100%
1991	29%	40%	28%	0%	1%	2%	100%
1992	20%	67%	12%	0%	0%	0%	100%
1993	87%	7%	1%	4%	0%	0%	100%
1994	40%	0%	34%	10%	17%	0%	100%
1995	30%	45%	21%	2%	3%	0%	100%
1996	2%	80%	17%	0%	1%	0%	100%
1997	14%	0%	80%	5%	1%	0%	100%
1998	42%	0%	0%	5%	53%	0%	100%
1999	70%	29%	0%	1%	1%	0%	100%
2000	77%	1%	0%	11%	10%	0%	100%
2001	37%	51%	1%	2%	9%	0%	100%
2002	34%	59%	0%	2%	4%	1%	100%
2003	39%	36%	0%	21%	3%	0%	100%
2004	47%	44%	1%	1%	3%	3%	100%
2005	55%	17%	0%	23%	1%	5%	100%
2006	23%	69%	2%	1%	5%	1%	100%
2007	19%	61%	5%	13%	0%	1%	100%
2008	62%	26%	3%	1%	4%	4%	100%
2009	38%	56%	1%	3%	1%	1%	100%
2010	16%	74%	2%	5%	1%	3%	100%
2011	34%	44%	2%	18%	2%	1%	100%
2012	30%	60%	3%	5%	1%	0%	100%
2013	28%	65%	0%	6%	1%	0%	100%

Table 65 - Southern red hake estimated commercial discards in metric tons (TOP) and percent (BOTTOM) by major gear groupings.

Year	Trawl_large mesh	Trawl small mesh	Scallop Dredge	Sink Gillnet	Longline	Total
1989	643.63	4917.34	0.00	0.00	0.00	5560.97
1990	1328.70	3352.21	0.00	0.00	0.00	4680.90
1991	445.29	2143.80	1.63	0.09	21.35	2612.16
1992	768.06	5519.00	20.58	3.30	0.00	6310.94
1993	8163.62	6404.06	17.18	4.76	0.00	14589.61
1994	641.52	2407.37	50.20	0.69	0.00	3099.77
1995	110.37	1248.92	27.47	0.45	0.00	1387.21
1996	237.02	341.23	19.29	0.19	0.00	597.72
1997	1012.93	2046.14	44.27	2.06	0.00	3105.40
1998	4754.53	712.63	2.37	0.45	0.00	5469.97
1999	3606.00	325.80	31.19	0.89	0.00	3963.87
2000	5695.34	118.85	63.70	7.62	0.00	5885.50
2001	1751.96	252.38	36.94	0.00	0.00	2041.28
2002	17.54	303.02	15.41	0.44	0.00	336.40
2003	18.23	285.56	5.42	1.28	0.00	310.48
2004	180.41	433.37	19.07	0.37	0.00	633.22
2005	136.20	907.02	38.52	0.24	0.03	1082.01
2006	99.08	464.33	64.29	0.01	0.09	627.80
2007	158.15	1356.99	15.99	0.00	0.02	1531.14
2008	148.78	456.85	46.21	0.03	13.09	664.96
2009	128.31	717.86	51.48	0.16	0.00	897.81
2010	83.22	591.31	31.24	0.30	0.00	706.06
2011	22.86	928.76	57.61	0.67	0.00	1009.90
2012	18.13	551.79	78.78	0.28	0.00	648.98
2013	7.33	545.64	29.05	0.20	0.00	582.21

Year	Trawl_large mesh	Trawl small mesh	Scallop Dredge	Sink Gillnet	Longline	Total
1989	12%	88%	0%	0%	0%	100%
1990	28%	72%	0%	0%	0%	100%
1991	17%	82%	0%	0%	1%	100%
1992	12%	87%	0%	0%	0%	100%
1993	56%	44%	0%	0%	0%	100%
1994	21%	78%	2%	0%	0%	100%
1995	8%	90%	2%	0%	0%	100%
1996	40%	57%	3%	0%	0%	100%
1997	33%	66%	1%	0%	0%	100%
1998	87%	13%	0%	0%	0%	100%
1999	91%	8%	1%	0%	0%	100%
2000	97%	2%	1%	0%	0%	100%
2001	86%	12%	2%	0%	0%	100%
2002	5%	90%	5%	0%	0%	100%
2003	6%	92%	2%	0%	0%	100%
2004	28%	68%	3%	0%	0%	100%
2005	13%	84%	4%	0%	0%	100%
2006	16%	74%	10%	0%	0%	100%
2007	10%	89%	1%	0%	0%	100%
2008	22%	69%	7%	0%	2%	100%
2009	14%	80%	6%	0%	0%	100%
2010	12%	84%	4%	0%	0%	100%
2011	2%	92%	6%	0%	0%	100%
2012	3%	85%	12%	0%	0%	100%
2013	1%	94%	5%	0%	0%	100%

Table 66 - 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 fall survey biomass the relative exploitation ratio from 2011-2013.

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
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

Table 67 - 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 fall survey biomass the relative exploitation ratio from 2011-2013.

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
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

Table 68 - 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 fall survey biomass the relative exploitation ratio from 2011-2013.

Year	Northern Spring Survey arithmetic kg/tow	Northern Spring Survey 3-year Average kg/tow	Total Northern Landings (000's mt)	Northern 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			3.79			3.79		
1961			3.28			3.28		
1962			1.91	1.60	0.01	3.52		
1963			3.28	1.60	0.00	4.89		
1964			1.41	1.70	0.00	3.11		
1965			2.77	1.62	0.00	4.40		
1966			5.58	1.60	0.00	7.18		
1967			1.86	1.40	0.00	3.27		
1968	1.14		2.63	1.30	0.00	3.93	3.45	
1969	0.64		2.02	1.12	0.00	3.14	4.91	
1970	0.54	0.77	1.03	1.10	0.00	2.13	3.94	4.10
1971	0.65	0.61	4.81	1.16	0.00	5.97	9.21	6.02
1972	1.56	0.92	15.03	0.96	0.00	15.99	10.25	7.80
1973	4.31	2.17	15.29	0.91	0.00	16.20	3.76	7.74
1974	2.43	2.77	7.22	0.82	0.00	8.04	3.31	5.77
1975	4.25	3.67	8.70	1.20	0.00	9.90	2.33	3.13
1976	3.37	3.35	6.34	0.93	0.00	7.26	2.15	2.60
1977	2.66	3.43	0.89	1.08	0.00	1.98	0.74	1.74
1978	2.57	2.87	1.22	1.12	0.00	2.34	0.91	1.27
1979	2.04	2.42	1.52	1.22	0.01	2.75	1.35	1.00
1980	3.88	2.83	1.03	1.37	0.00	2.40	0.62	0.96
1981	6.35	4.09	1.25	1.32	0.03	2.60	0.41	0.79
1982	2.13	4.12	1.21	1.46	0.00	2.67	1.26	0.76
1983	3.70	4.06	0.90	1.35	0.00	2.25	0.61	0.76
1984	2.98	2.94	1.06	1.33	0.00	2.39	0.80	0.89
1985	3.91	3.53	0.99	1.27	0.00	2.26	0.58	0.66
1986	3.26	3.39	1.46	1.19	0.00	2.65	0.81	0.73
1987	2.94	3.37	1.01	1.05	0.00	2.07	0.70	0.70
1988	2.00	2.73	0.86	0.90	0.00	1.76	0.88	0.80
1989	1.65	2.20	0.78	1.45	0.00	2.22	1.35	0.98
1990	1.33	1.66	0.83	0.60	0.00	1.43	1.07	1.10
1991	1.62	1.53	0.74	0.82	0.00	1.56	0.96	1.13
1992	2.50	1.82	0.92	0.73	0.00	1.65	0.66	0.90
1993	2.82	2.32	0.77	0.08	0.00	0.85	0.30	0.64
1994	1.59	2.31	0.73	0.08	0.00	0.81	0.51	0.49
1995	1.97	2.13	0.19	0.06	0.00	0.25	0.13	0.31
1996	1.79	1.79	0.41	0.66	0.01	1.07	0.60	0.41
1997	1.81	1.86	0.34	0.13	0.00	0.46	0.26	0.33
1998	2.52	2.04	0.19	0.13	0.00	0.32	0.13	0.33
1999	2.32	2.22	0.22	0.47	0.00	0.69	0.30	0.23
2000	3.19	2.68	0.20	0.06	0.00	0.25	0.08	0.17
2001	3.58	3.03	0.22	0.14	0.00	0.36	0.10	0.16
2002	4.46	3.74	0.28	0.10	0.00	0.38	0.08	0.09
2003	1.00	3.01	0.21	0.09	0.00	0.30	0.30	0.16
2004	1.77	2.41	0.10	0.06	0.00	0.16	0.09	0.16
2005	1.10	1.29	0.10	0.06	0.00	0.15	0.14	0.18
2006	0.91	1.26	0.10	0.18	0.00	0.28	0.30	0.18
2007	2.06	1.36	0.07	0.13	0.00	0.20	0.10	0.18
2008	3.49	2.15	0.05	0.06	0.00	0.11	0.03	0.14
2009	1.75	2.43	0.09	0.10	0.00	0.18	0.10	0.08
2010	2.02	2.42	0.07	0.24	0.00	0.31	0.15	0.10
2011	2.18	1.98	0.14	0.10	0.00	0.24	0.11	0.12
2012	1.73	1.98	0.10	0.19	0.00	0.29	0.17	0.14
2013	1.35	1.75	0.10	0.22	0.00	0.31	0.23	0.1691
2014	3.02	2.03						

Table 69 - 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 (2011-2013) and the relative exploitation ratios from 2011-2013.

Year	Southern Spring Survey arithmetic kg/tow	Southern Spring Survey 3-year Average kg/tow	Total Southern Landings (000's mt)	Southern 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	0.89	16.76		
1963			31.90	4.00	0.77	36.67		
1964			43.37	3.76	0.85	47.98		
1965			92.99	4.29	0.63	97.92		
1966			107.92	3.77	0.09	111.79		
1967			58.78	3.66	0.17	62.61		
1968	1.29		18.14	3.72	0.58	22.43	17.45	
1969	1.08		52.93	3.62	0.49	57.04	52.72	
1970	1.72	1.36	11.45	3.14	0.41	15.01	8.71	26.29
1971	3.49	2.10	35.13	2.31	0.29	37.73	10.82	24.08
1972	3.59	2.93	61.19	2.10	0.18	63.47	17.68	12.40
1973	3.99	3.69	51.36	2.24	0.32	53.92	13.51	14.00
1974	2.84	3.47	26.64	2.16	0.19	28.99	10.22	13.80
1975	3.18	3.34	19.98	1.76	0.05	21.79	6.85	10.19
1976	5.31	3.78	22.47	1.83	0.65	24.94	4.69	7.25
1977	2.30	3.60	7.06	1.82	0.75	9.63	4.19	5.24
1978	7.65	5.09	5.46	2.44	0.97	8.87	1.16	3.35
1979	1.51	3.82	7.59	2.67	0.25	10.50	6.94	4.09
1980	2.38	3.85	4.08	2.70	0.14	6.93	2.91	3.67
1981	4.61	2.84	2.32	2.72	0.18	5.21	1.13	3.66
1982	3.34	3.45	3.17	3.78	0.03	6.98	2.09	2.04
1983	2.21	3.39	1.44	3.89	0.14	5.47	2.48	1.90
1984	1.33	2.29	1.27	3.91	0.55	5.73	4.30	2.96
1985	1.39	1.64	0.90	2.97	0.03	3.90	2.80	3.19
1986	1.73	1.49	0.69	3.39	0.21	4.29	2.47	3.19
1987	0.88	1.33	0.94	3.31	0.47	4.73	5.38	3.55
1988	1.01	1.21	0.87	3.46	0.25	4.58	4.56	4.14
1989	0.49	0.79	0.93	5.01	0.44	6.37	13.09	7.68
1990	0.71	0.73	0.80	4.75	0.51	6.06	8.57	8.74
1991	0.61	0.60	0.93	2.61	0.29	3.82	6.26	9.30
1992	0.47	0.59	1.25	6.34	0.19	7.78	16.74	10.52
1993	0.42	0.50	0.92	5.31	0.09	6.32	14.91	12.63
1994	0.68	0.52	0.98	1.72	0.07	2.77	4.11	11.92
1995	0.52	0.54	1.43	1.33	0.05	2.80	5.43	8.15
1996	0.45	0.55	0.70	0.38	0.02	1.10	2.43	3.99
1997	1.16	0.71	1.00	2.42	0.17	3.59	3.10	3.65
1998	0.21	0.61	1.15	0.74	0.05	1.95	9.10	4.87
1999	0.46	0.61	1.35	1.06	0.05	2.46	5.42	5.87
2000	0.42	0.36	1.42	0.25	0.04	1.71	4.04	6.19
2001	0.64	0.51	1.47	0.14	0.02	1.63	2.54	4.00
2002	0.54	0.54	0.66	0.33	0.01	1.00	1.85	2.81
2003	0.21	0.46	0.62	0.35	0.02	0.99	4.79	3.06
2004	0.15	0.30	0.59	0.62	0.01	1.21	7.88	4.84
2005	0.38	0.25	0.36	1.01	0.06	1.42	3.77	5.48
2006	0.38	0.30	0.38	0.67	0.05	1.10	2.90	4.85
2007	0.86	0.54	0.47	1.55	0.02	2.04	2.37	3.02
2008	0.47	0.57	0.58	0.81	0.07	1.47	3.10	2.79
2009	1.34	0.89	0.58	0.87	0.10	1.54	1.15	2.21
2010	0.92	0.91	0.58	0.74	0.09	1.41	1.52	1.93
2011	1.79	1.35	0.50	1.01	0.115	1.62	0.91	1.19
2012	1.06	1.26	0.75	0.65	0.037	1.44	1.36	1.26
2013	0.64	1.16	0.44	0.58	0.076	1.10	1.71	1.32
2014	0.73	NA						

13.0 Assessment Figures

Figure 34 - Map of management and assessment area used for both silver hake and red hake stocks (Northern stock: 512-515, 521-522 and 561. Southern stock: 525-526, 562, 533-534, 537-539, 541-543, 611-616, 621-623, 625-628, 631-638). The dots represent the management and assessment area used for offshore hake.

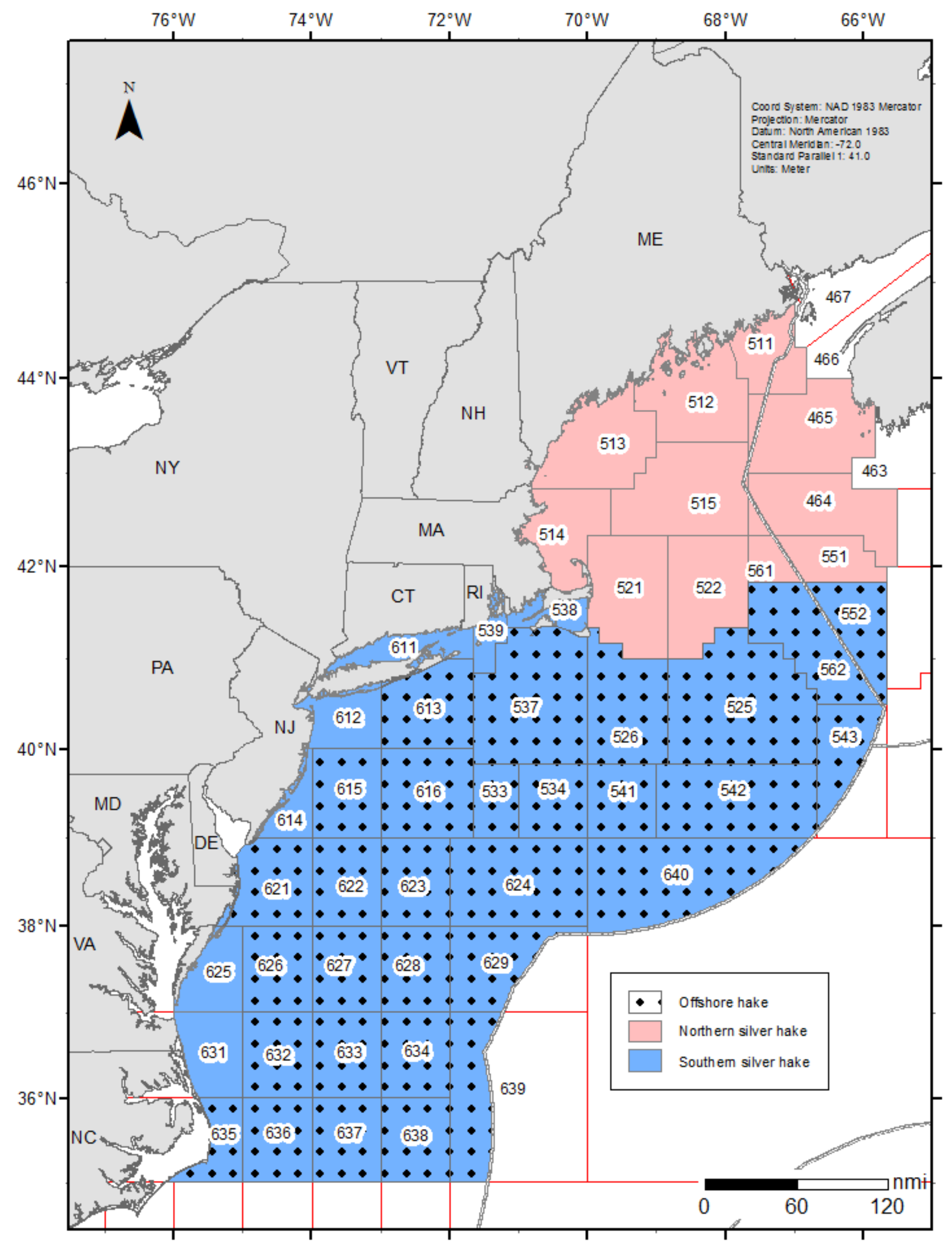
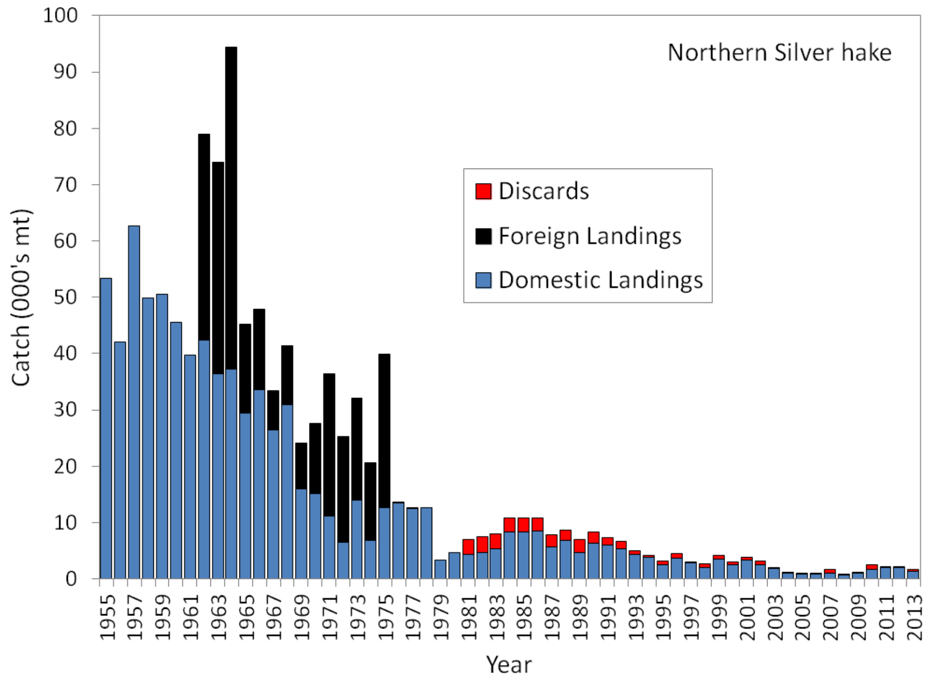


Figure 35 - Summary of total catch (mt) for both northern (TOP) and southern (BOTTOM) ***silver hake*** stocks by dispositions (landed and discarded) from 1955-2013. Note: Landings include VTR bait landings and are not disaggregated for confidential reasons.



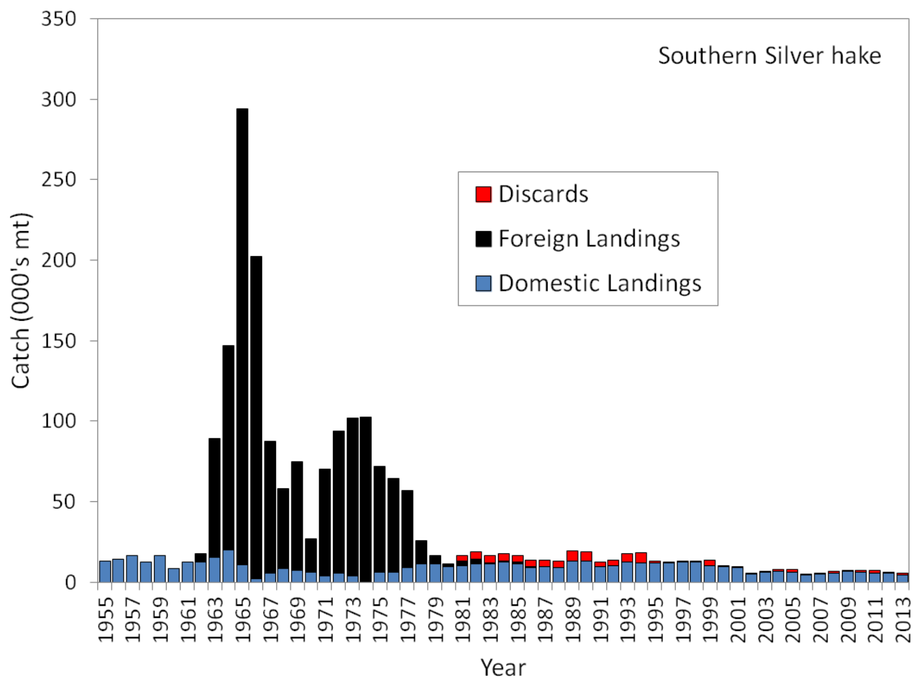
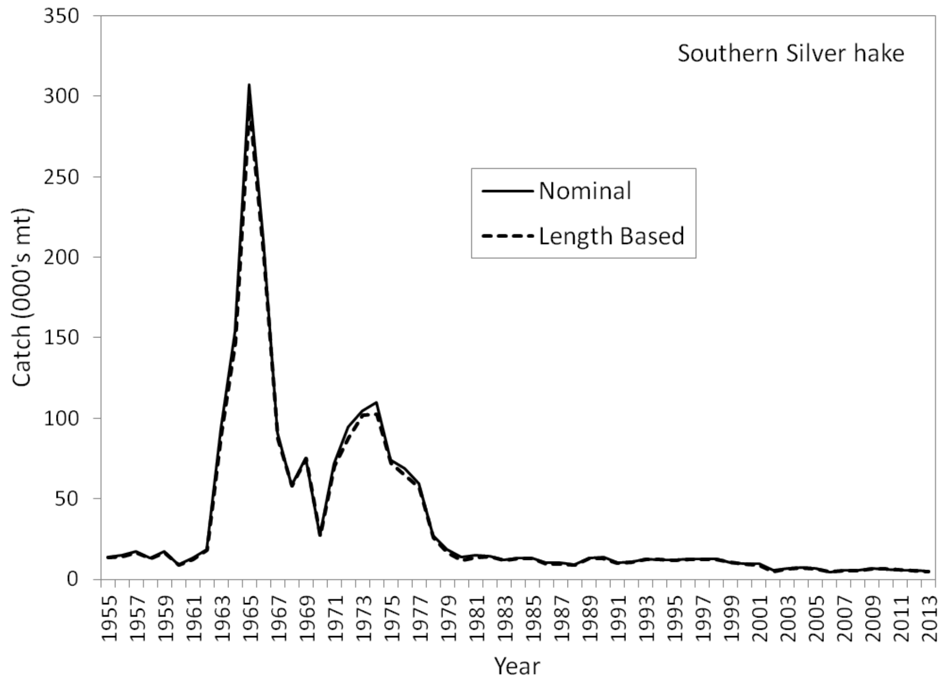


Figure 36 - Comparison of model-based landings to dealer reported landings of silver hake (TOP), and percent offshore hake in the ***Southern whiting*** (BOTTOM) derived from the length-based model for years 1955-2013



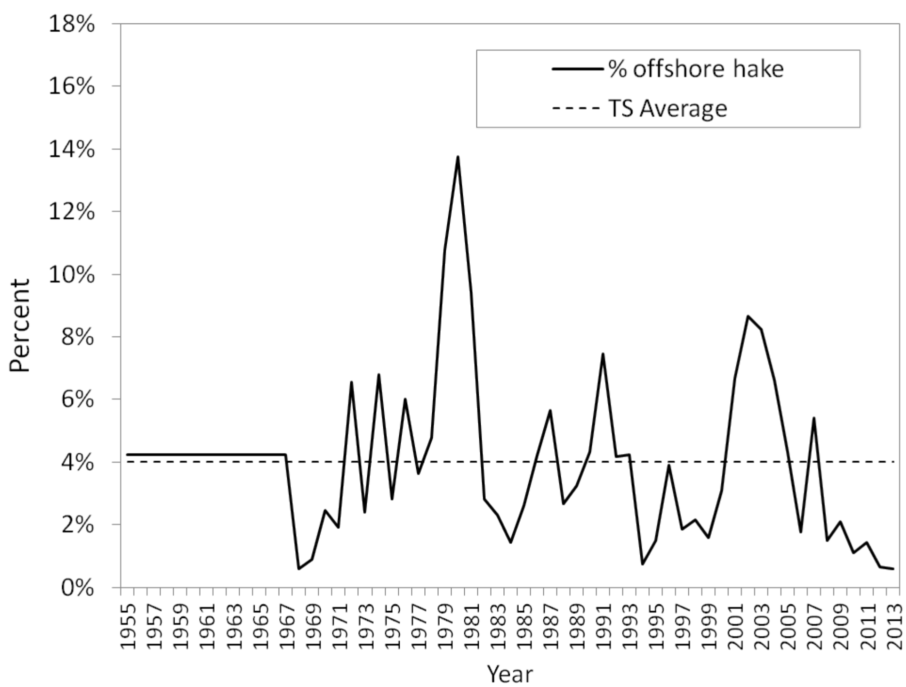
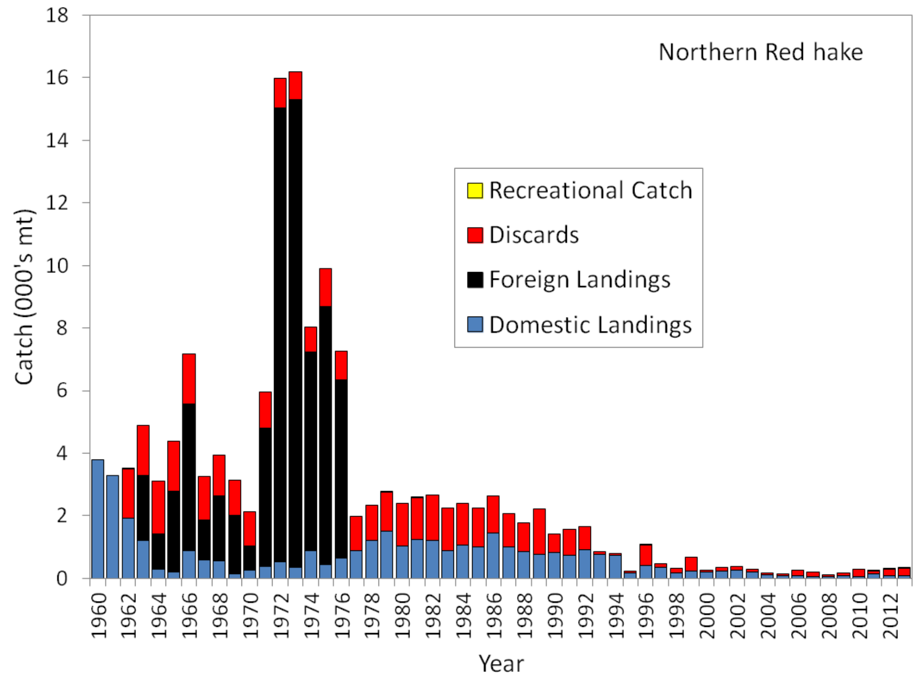


Figure 37 - Total catches (mt) of both northern (TOP) and southern (BOTTOM) ***red hake*** stocks by catch dispositions (landed and discarded) for years 1955-2013.



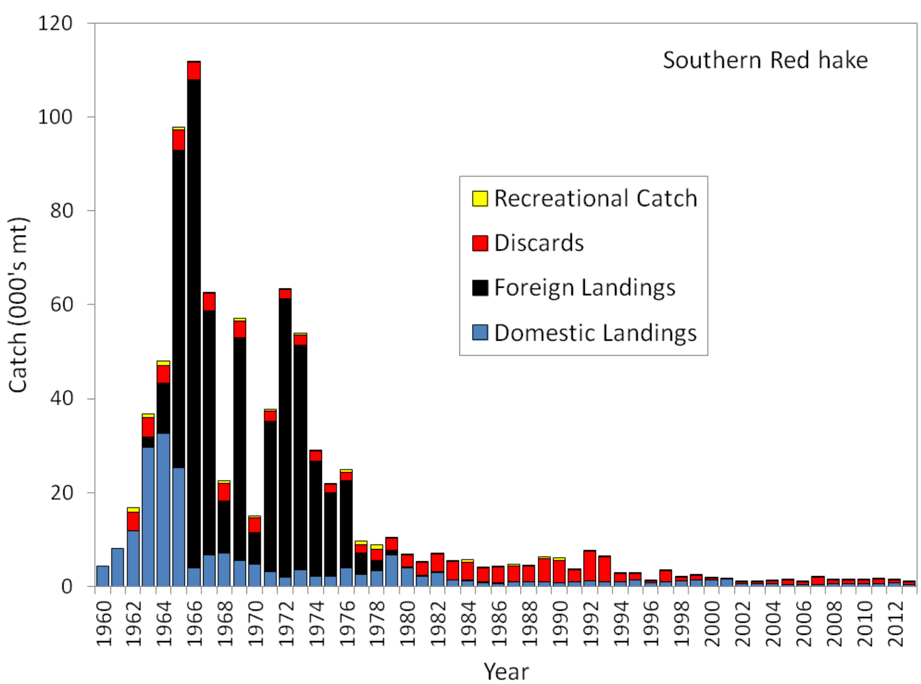


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Figure 38 - Estimated commercial landings of northern (TOP) and southern (BOTTOM) **silver hake** by major gear groupings from 1994-2013 expressed nominal values (LEFT) and as percent (RIGHT).

North Silver hake

South Silver hake

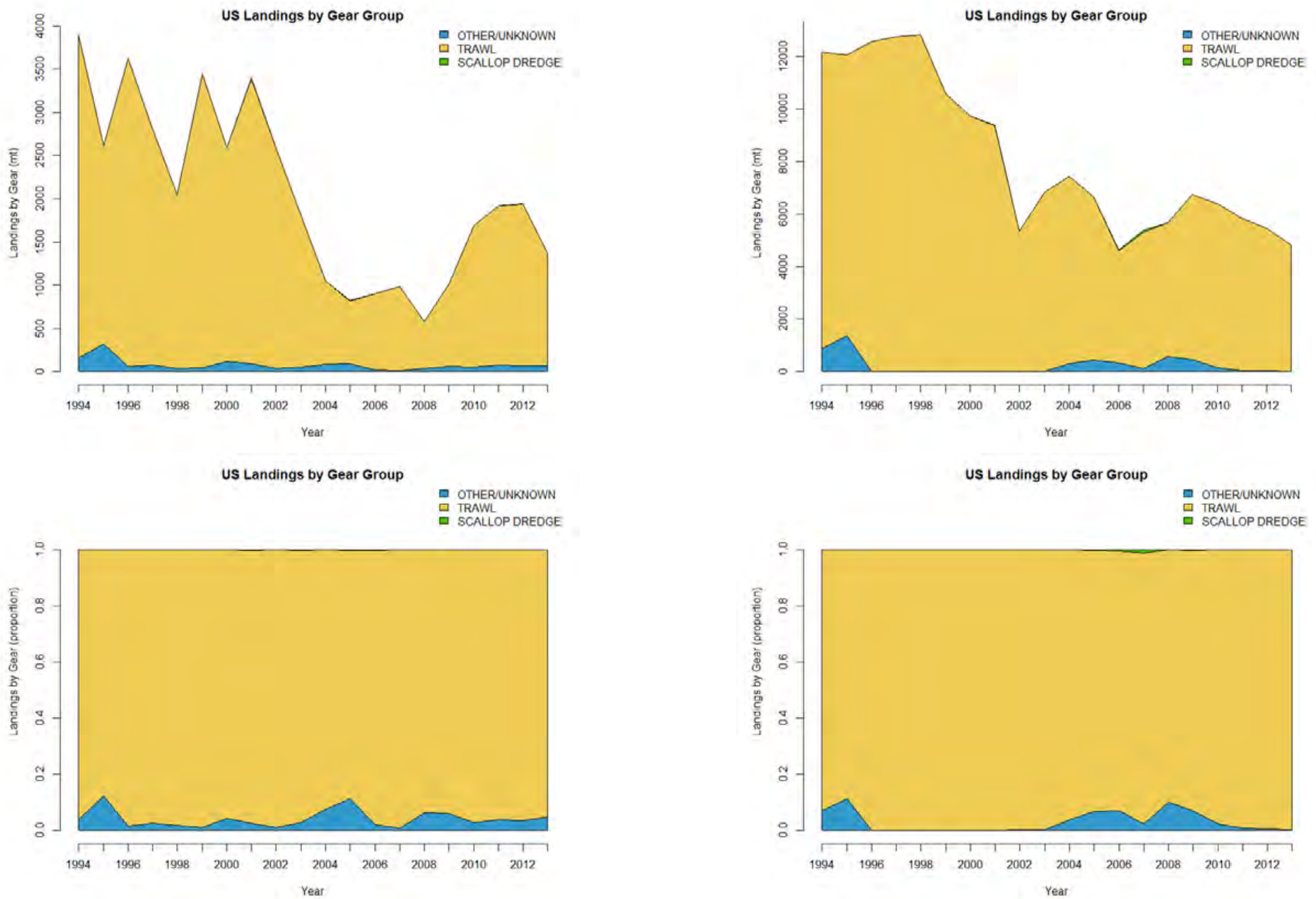
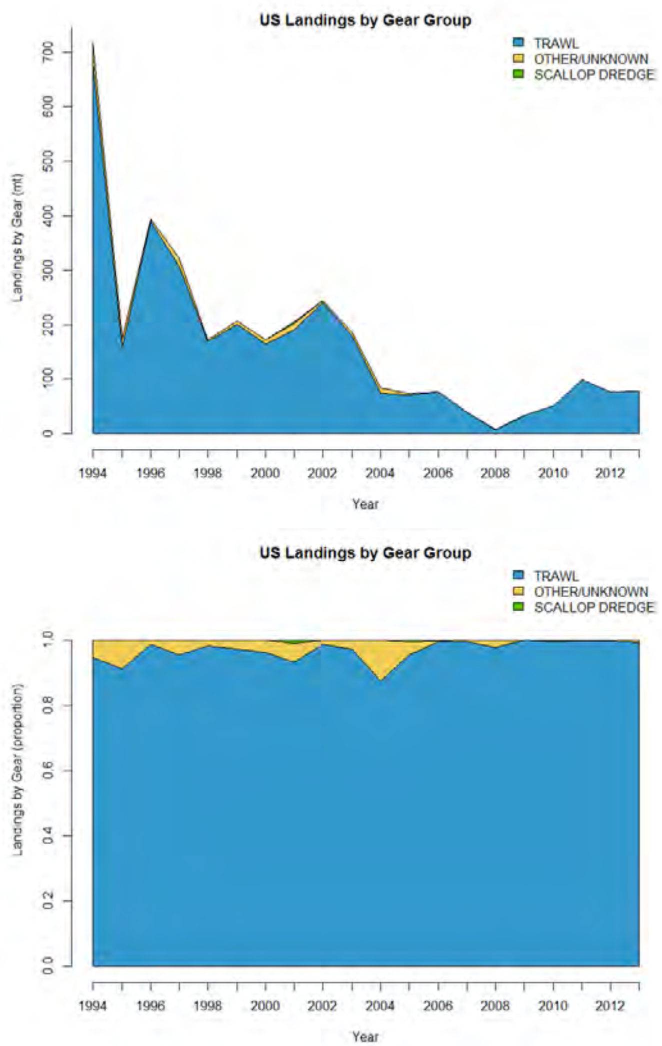


Figure 39. Estimated commercial landings of northern (TOP) and southern (BOTTOM) **red hake** by major gear groupings from 1994-2013 expressed nominal values (LEFT) and as percent (RIGHT)

North Red hake



South Red hake

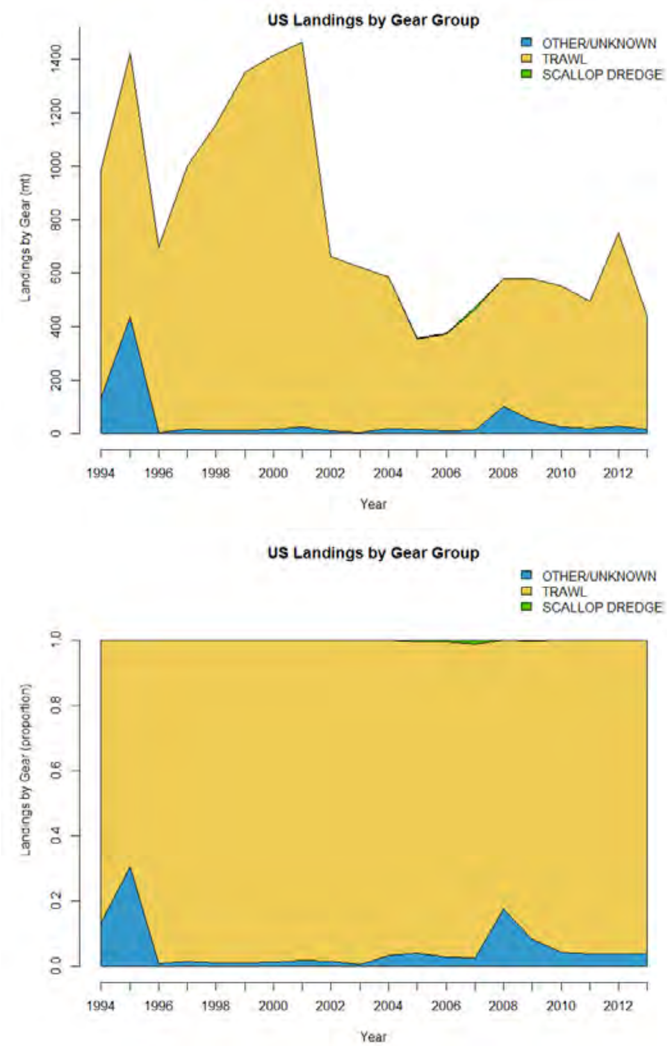


Figure 40 - Estimated commercial discards of northern (LEFT) and southern (RIGHT) **silver hake** by major gear groupings from 1994-2013 expressed nominal values (TOP) and as percent (BOTTOM).

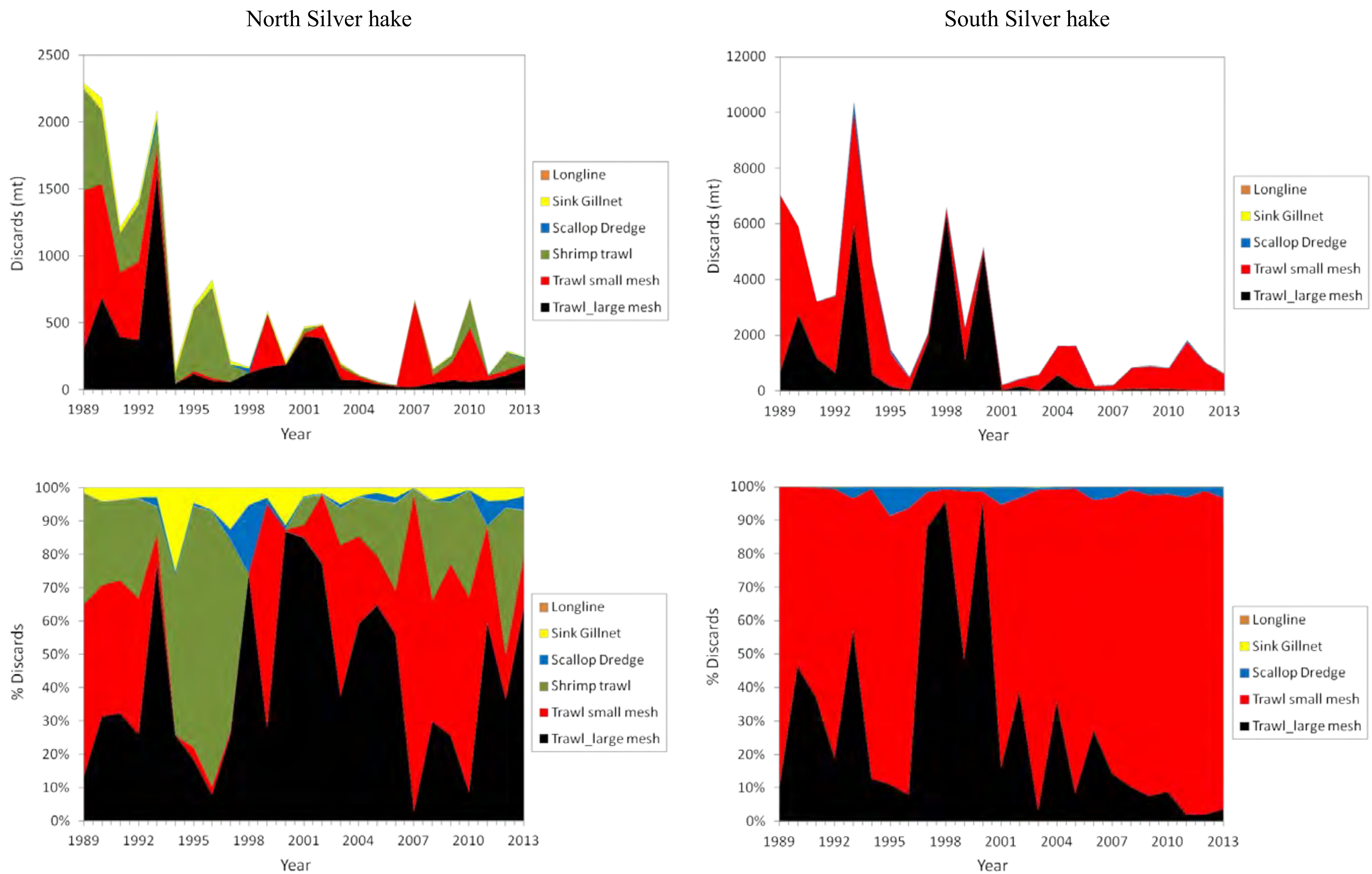


Figure 41 - Commercial discards of northern (LEFT) and southern (RIGHT) **red hake** by major gear groupings from 1994-2013 expressed nominal values (TOP) and as percent (BOTTOM).

North Red hake

South Red hake

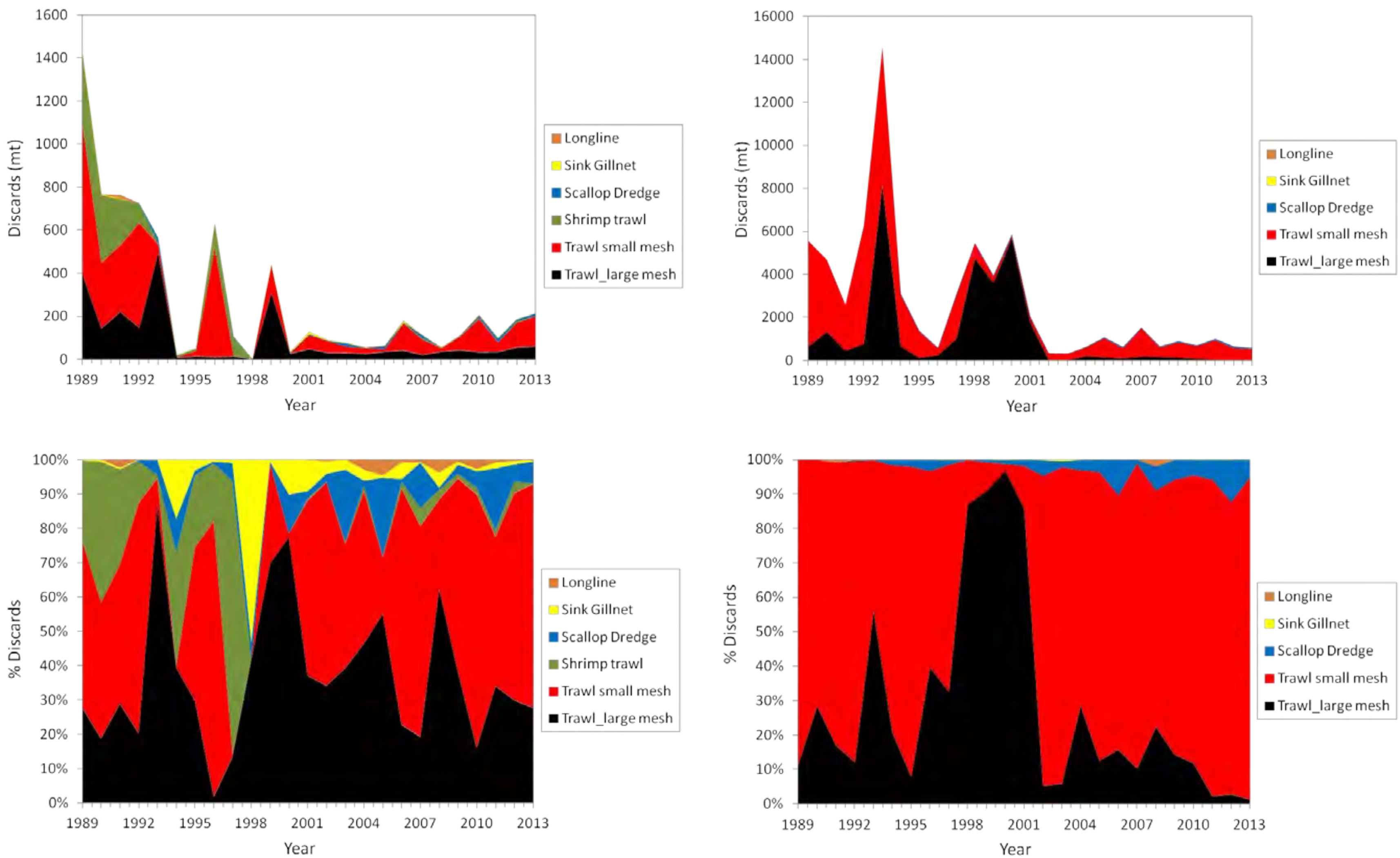


Figure 42 - Recreational catches of northern (TOP) and southern (BOTTOM) **red hake** stocks derived from the Marine Recreation Information Program (MRIP) from 2004-2013.

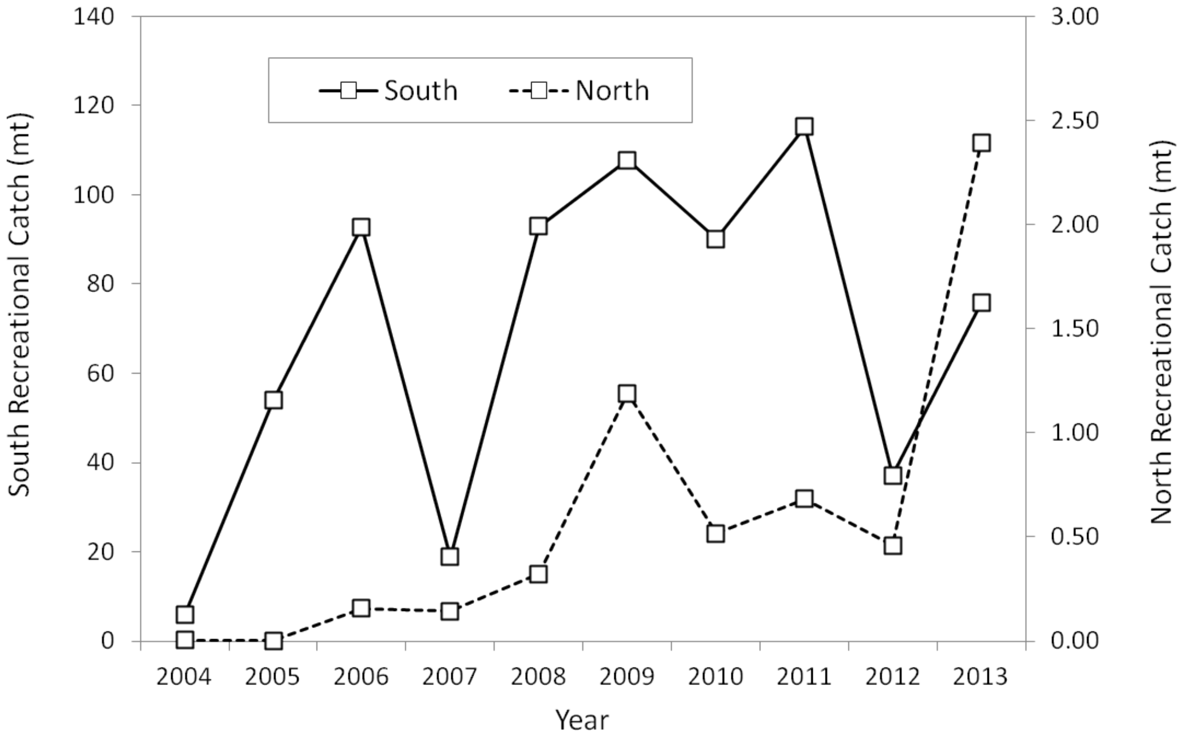


Figure 43 - Map of the Northeast Fisheries Science Center (NEFSC) bottom trawl offshore survey strata included in the northern (20-30 and 36-40) and southern (01-19 and 61-76) silver and red hake stock assessment update and previous assessments.

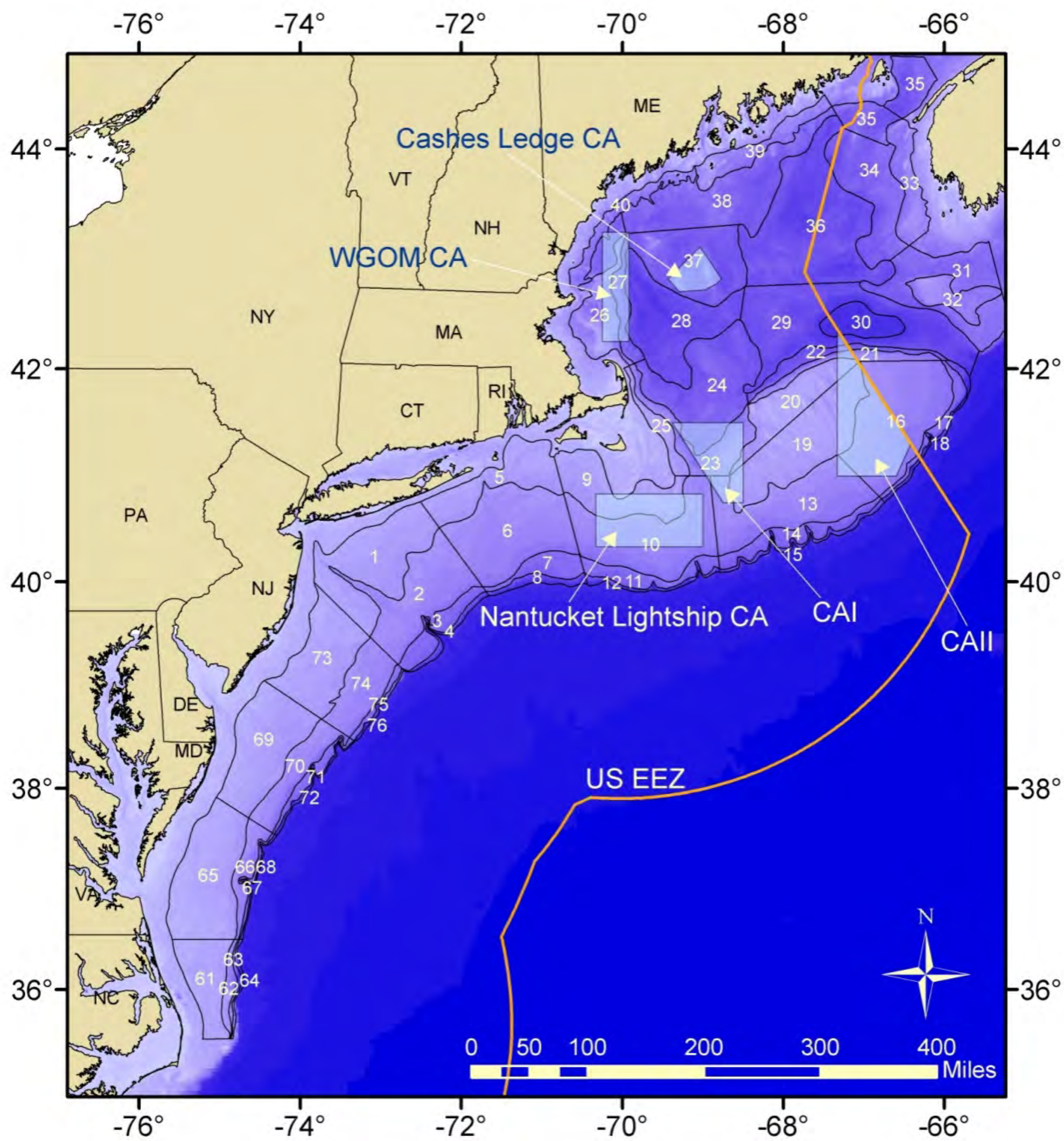


Figure 44 - Northeast Fisheries Science Center fall survey index of biomass (kg/tow) and estimated coefficient of variation (CV) for both northern (LEFT) and southern (RIGHT) ***silver hake*** in Albatross units from 1963-2013. Bottom panels show both unconverted estimates from FSV H. Bigelow vessel (2009-2013). Note: The autumn survey is the basis for the assessment update for this stock.

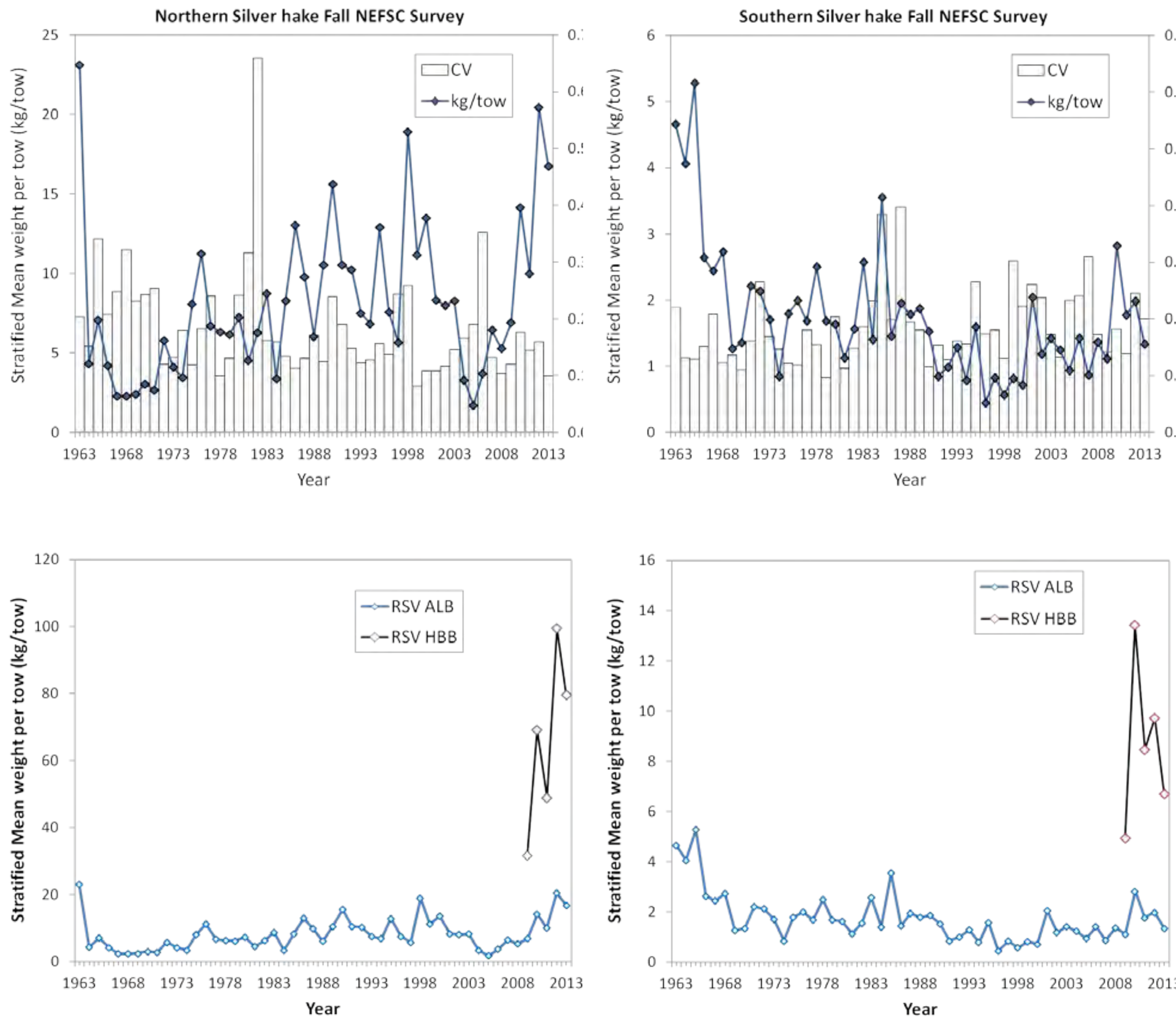


Figure 45 - Northeast Fisheries Science Center spring survey index of biomass (kg/tow) and estimated coefficient of variation (CV) for both northern (TOP) and southern (BOTTOM) ***red hake*** in Albatross units from 1968-2014. Bottom panels show both unconverted estimates from FSV H. Bigelow vessel (2009-2014). Note: The spring survey is the basis for the assessment update for this stock. In the south, 2014 estimate (black circle and CV in red) were excluded in this update due lack of full coverage of the survey in the southern stock.

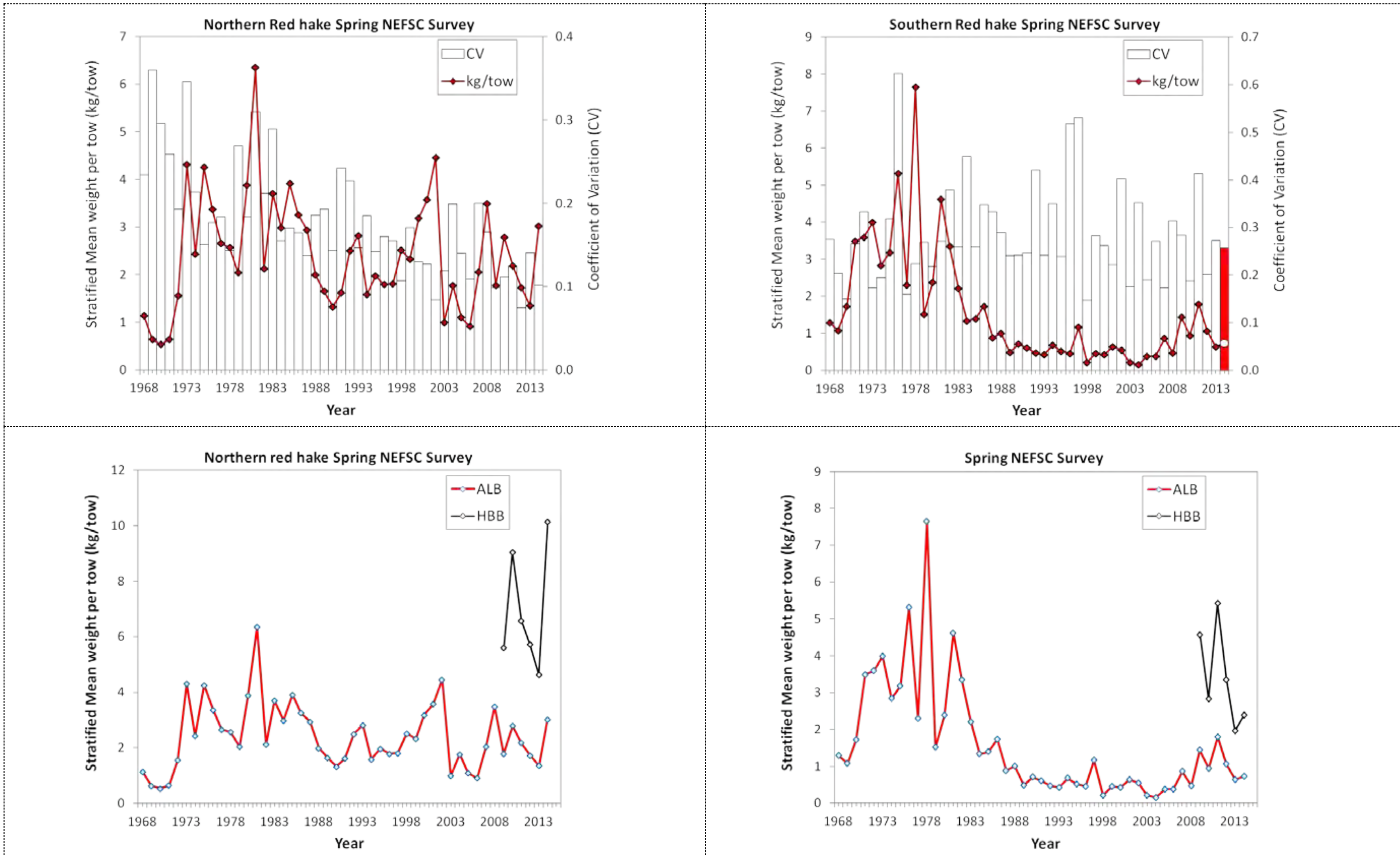
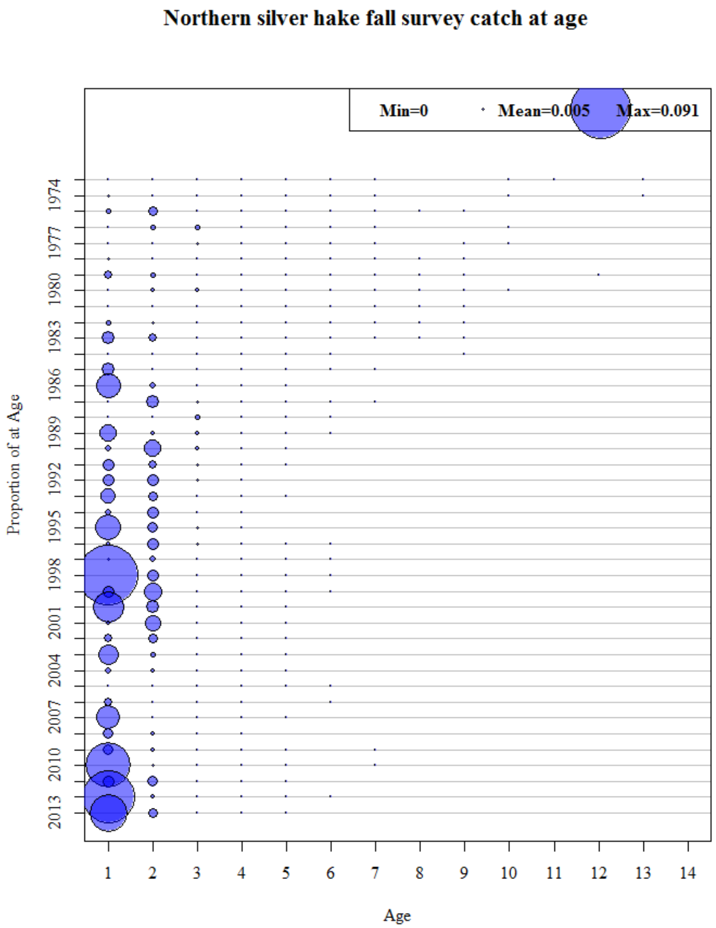


Figure 46 - Numbers-at-age from the NEFSC autumn trawl survey from 1963 to 2013 for both northern (LEFT) and southern (RIGHT) ***silver hake*** stocks.



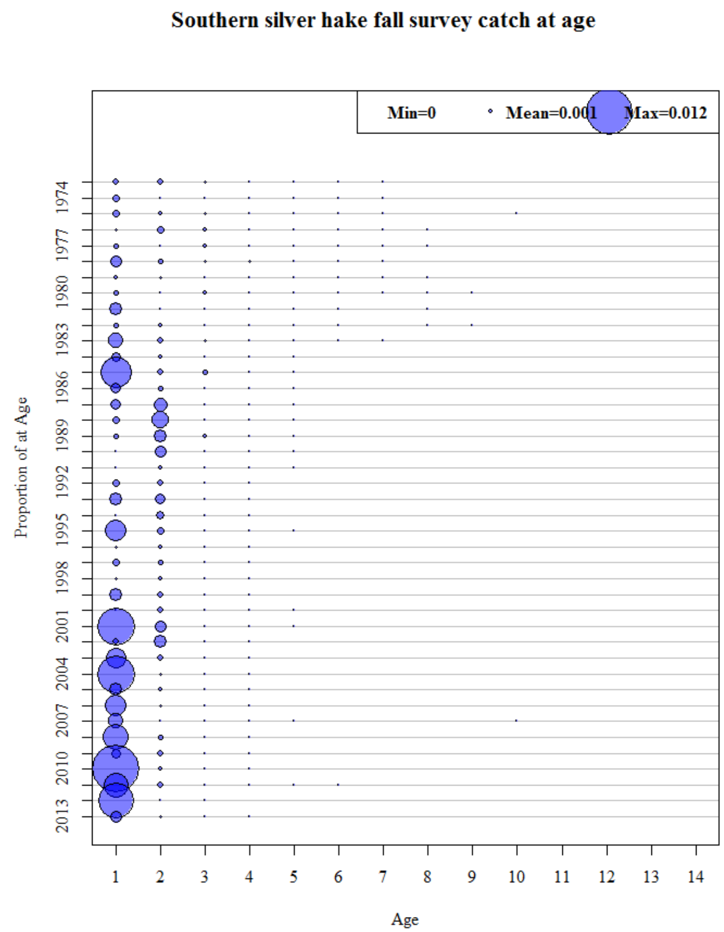
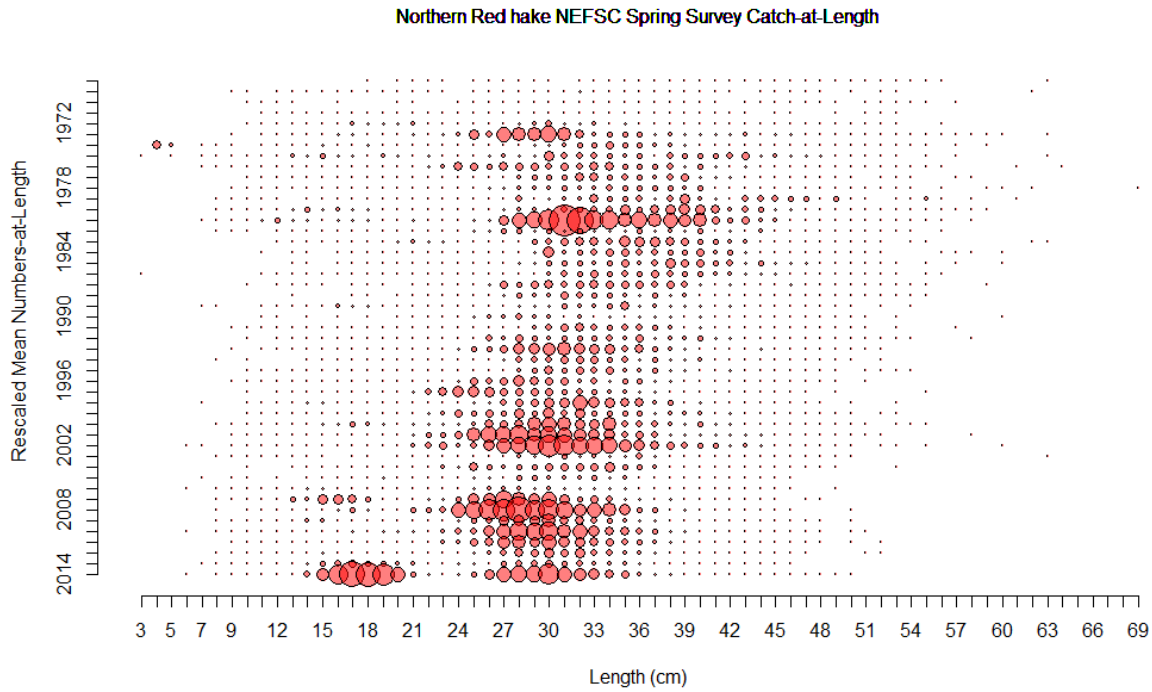
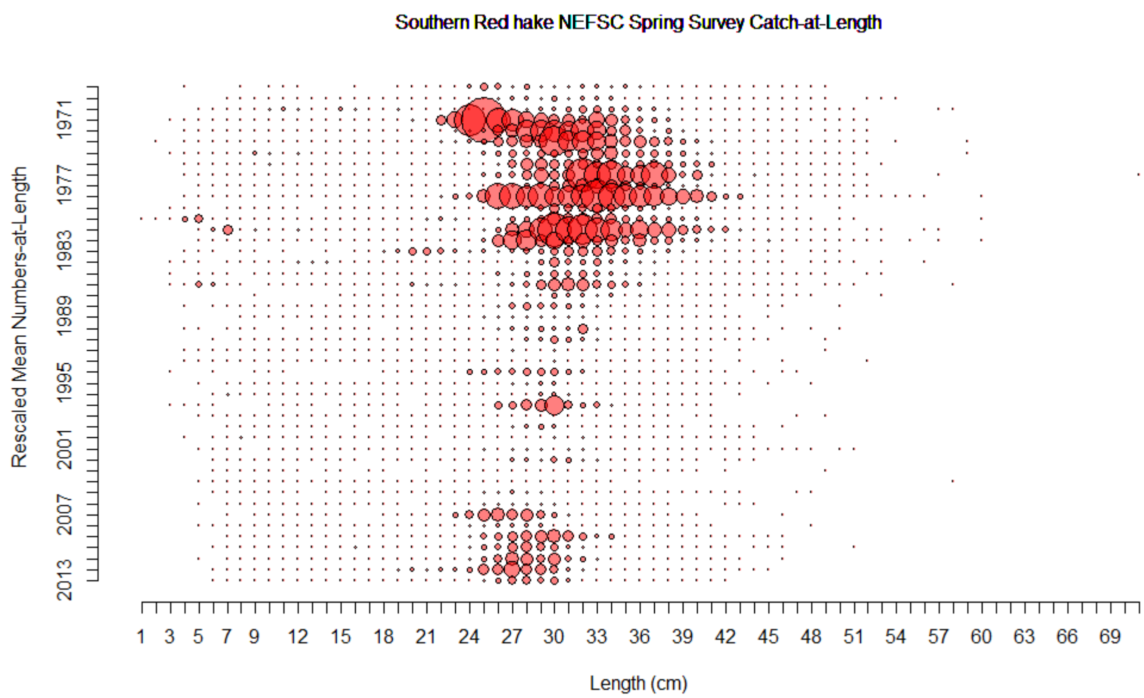


Figure 47 - Catch-at-length from the NEFSC spring trawl survey from 1968 to 2014 for both northern (TOP) and southern (BOTTOM) ***red hake*** stocks





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