3.3 Results from the Bering Sea NMFS trawl survey in 2016

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Abstract

The National Marine Fisheries Service groundfish trawl survey has taken place since 1979 and the International Pacific Halibut Commission (IPHC) has participated in the survey on an annual basis since 1998 by directly sampling Pacific halibut from survey catches. The 2016 standard survey took place aboard two vessels from 28 May to 3 August. IPHC field biologists were deployed on the *F/V Vesteraalen* for all trips. Lengths were collected for all Pacific halibut caught on both vessels. On the vessel staffed by IPHC, a total of 1,329 Pacific halibut were encountered. The Pacific halibut caught were randomly divided into two groups; biological sampling and tagging. In the tagging group, only those fish < 82 cm fork length were tagged and released while the remainder were measured and released as soon as possible. A total of 556 Pacific halibut otoliths were collected along with, sex, maturity, and prior hooking injury information, and 424 fish were tagged and released. One hundred ninety-eight tissue samples for energetics analysis were obtained from a portion of the otolithed fish and fin clips for genetic analysis were obtained from both those fish and all tagged Pacific halibut. The Bering Sea abundance estimate was 66 million fish which is slightly higher than the estimate for 2015. The total biomass was estimated at 338.8 million pounds (153,677 t) which was substantially lower than the 2015 estimate of 380 million pounds (172,365 t).

Introduction

The National Marine Fisheries Service (NMFS) has conducted annual bottom trawl surveys on the eastern Bering Sea (EBS) continental shelf since 1979. The survey was standardized in 1982 and an International Pacific Halibut Commission (IPHC) field biologist has been deployed on the survey every year since 1998 to collect Pacific halibut (*Hippoglossus stenolepis*) samples. The IPHC operates a coastwide longline survey as the primary fishery-independent source of data for the Pacific halibut stock assessment (Henry et al. 2017). However, Pacific halibut occupy a vast area of the Bering Sea shelf for which the IPHC lacks the financial resources to sample in its entirety on a regular basis. Therefore, in most years, the NMFS trawl survey is the only measure of abundance for much of this area. This paper presents abundance and biomass estimates for the EBS for the years 1982-2016, age composition for 2015, and results from the 2016 survey.

Survey trawl gear has different size-selectivity than setline gear, making it necessary to apply a selectivity curve to include these data directly in the Pacific halibut stock assessment that is generated by the IPHC. Pacific halibut are vulnerable to the trawl from about 20-100 cm fork length (FL) (Clark et al. 1997), but a substantial portion of the commercial-sized population (O32 or ≥ 81.3 cm FL) exceeds 100 cm. In 2006, and again in 2015, the IPHC added shelf stations to its setline survey in the Bering Sea region in order to compare information from these stations with data collected on the NMFS trawl survey. After the study in 2006, the IPHC staff concluded that the trawl survey, along with periodic IPHC survey calibrations, provided an adequate accounting of Pacific halibut biomass on the EBS shelf (Clark and Hare 2007) and is a useful tool for

constructing a population-density index for the IPHC stock assessment (Webster 2014). The 2015 calibration confirmed this earlier finding. In addition to its use as a stock assessment tool, trawl survey information is useful as a forecasting tool for cohorts approaching recruitment into the commercial fishery.

In 2015, an IPHC sampler was placed aboard the EBS trawl survey for the 18th consecutive year. Two chartered fishing vessels, *F/V Vesteraalen* and *F/V Alaska Knight*, were each staffed by six scientific crew. The scientists carried out objectives related to stock assessment and year-class strength estimation for numerous species. The IPHC biologist was deployed on the *F/V Vesteraalen* to sample the Pacific halibut caught and to help NMFS personnel achieve their survey goals.

Objectives

The main objectives for the IPHC biologist in 2016 were:

- Take the fork length on 100% of the Pacific halibut caught on all standard groundfish tows;
- Collect sex, maturity, and prior hooking injury (PHI) data on 50% of the catch;
- Assess viability using NMFS observer criteria on the other 50% of the catch, and subsequently tag and release all those individuals that were determined to be viable and that were < 82 cm fork length. Measure and release those ≥ 82 cm fork length as soon as possible;
- Obtain tissue samples from a subsample of Pacific halibut for energetics analysis;
- Ship a maximum of 75, opportunistically collected, whole Pacific halibut measuring < 40 cm fork length back to the IPHC laboratory in Seattle, WA;
- Obtain fin clips from all tagged Pacific halibut and from the subsample of Pacific halibut selected for tissue samples.

The primary NMFS objective was to continue the annual series of crab and groundfish assessment surveys for the eastern Bering Sea to provide information to the following groups:

- The North Pacific Fishery Management Council for understanding the distribution, abundance, and biological condition of important groundfish and crab resources;
- The U.S. fishing industry for catch-per-unit-effort and size composition of commercially important groundfish species; and
- Stock assessment scientists to support ongoing studies on the biology, behavior, and dynamics of key ecosystem components.

Survey design, vessels, and itinerary

The current standard trawl survey includes 376 stations on a 20-nmi (1 nmi = 1.852 km) square grid design extending from inner Bristol Bay to St. Matthew Island, within the 200-m depth contour. The stations (Fig. 1) are placed at the center of each grid square, and additional stations are placed at the corners of grid cells in areas surrounding St. Matthew and the Pribilof Islands to better assess blue king crab (*Paralithodes platypus*) density.

In 1987, twenty stations were added north of the standard survey sampling area to better assess abundance and distribution of walleye pollock (*Gadus chalcogrammus*) and snow crab (*Chionoecetes opilio*) populations. Data from these stations are included in the abundance estimates herein. From 2000 to 2004, and again from 2011 to 2012, several stations within the 0-30 m depth stratum were added to investigate the nearshore distribution of either juvenile yellowfin

sole (*Limanda aspera*) or red king crab (*Paralithodes camtschaticus*). Some Pacific halibut were caught at these nearshore stations but the results were not incorporated into the NMFS abundance estimates because the stations were not part of the standard grid.

Since 1982, the EBS has been surveyed using a NMFS 83-112 Eastern trawl with a 25.3 m headrope and 34.1 m footrope. The trawl net was deployed with equipment that recorded data describing each tow. Through 2012, a Netmind[1] trawl mensuration system recorded net height and width, a Sea-Bird[2] data logger recorded temperature and depth, and a tilt sensor was used to detect when the footrope hit the bottom. In 2013, the Netmind system was replaced with the Marport[3] trawl mensuration system. A 30-minute tow was attempted at each station.

In 2016, the survey charter began on 26 May. Following several days of set-up and equipment testing, the *F/V Vesteraalen* left Dutch Harbor, AK on 29 May and conducted the first standard survey tow on 30 May. The charter concluded in Dutch Harbor on 27 July.

Pacific halibut sampling in 2016

Pacific halibut were measured on all standard survey tows aboard both vessels. Pacific halibut from tows aboard the IPHC-staffed vessel were assigned randomly into one of two groups: one for biological sampling, and one for wire tagging; with the goal of assigning 50% of the fish to each group. This was achieved by laying out two fish at a time, rolling a set of dice, then assigning one fish to each group based on predetermined number designations. This step was repeated until all the fish were sorted. Fish in the tagging sample were kept briefly in a live tank while sorting was taking place, and then assessed for condition using NMFS observer criteria. Those with an assessment of Excellent and Poor were outfitted with a wire tag through the operculum. Those assessed in the Dead category were measured and discarded. A fin clip was obtained from each tagged fish for genetic analysis. For a full description of the tagging project, see Forsberg et al. (2016).

Fish in the biological sample group were assessed for sex, maturity, and prior hooking injuries, and the otolith was removed for aging. An additional subsample was selected for flesh sample removal as part of an energetics study and fin clips which will be used for a genetics study. Pacific halibut caught in tows at corner crab stations, and during duplicate tows, were excluded from the regular sample.

Sex and maturity determinations were made via macroscopic gonad examination for each biologically sampled Pacific halibut, which is described in detail in the survey manual (IPHC Unpub). Female fish were assigned to one of four stages of maturity: immature, ripening, ripe/spawning, and spent/resting. Males were assigned tone of two maturity stages: immature and mature. Immature fish, regardless of sex, were those that would not be expected to participate in the upcoming spawning season. The other stages represented various phases of the spawning process. Fish in those categories were considered mature enough that they could participate in the upcoming spawning season.

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Information concerning injuries to the mouth, jaw, or eye caused from longline gear (i.e., PHIs) has been collected in recent years as part of an IPHC special project. The objective was to assess the types of PHIs a fish might sustain and still survive.

Once the raw data and samples are collected at sea, there are several aspects of processing that occur to make the information useable. Pacific halibut ages are acquired by reading the otoliths from each fish, and this procedure is detailed in Forsberg (2001). By 2003, all commercial and setline survey otoliths were read using the break-and-bake technique, but this procedure works better for older fish, whereas surface reading is better for the youngest fish. Therefore, trawl otoliths continue to be read using a combination of the two techniques. Aging of Pacific halibut in the 2016 sample has not been completed, so age composition information in this report includes data through the previous survey. All Pacific halibut caught during the surveys on all vessels are measured for fork length and weighed. Swept-area estimates of abundance and biomass are calculated using these lengths and weights, the procedure for which is outlined in Clark et al. (1997) and Stauffer (2004).

Results

A total of 191 tows were performed by the *F/V Vesteraalen*. On average, between four and five tows were conducted daily. A total of 2,248 Pacific halibut were encountered by both vessels during the survey (Fig. 2). The *F/V Vesteraalen* sample consisted of 1,329 Pacific halibut (Fig. 3). Of those, 556 otoliths were collected and 424 Pacific halibut were released with wire tags. Those fish > 82 cm and selected for the tagging sample were released alive if possible. If they were assessed as "Dead," then only biological information was collected (sex, maturity, and PHI). Of the sampled fish, 54% were female and 46% were male, which was the same as in 2015. Ninety-eight percent of the females and 11% of the males were assessed as immature (Table 1). PHIs were found on 2.9% of the sampled fish; 12 had minor damage, 10 had moderate damage, and none had severe damage. A total of 198 tissue samples were taken for an energetics study.

Length and age distribution

Total Pacific halibut abundance in the EBS as estimated using the trawl survey catches in 2016 (Fig. 4) was 66 million halibut, slightly higher than in 2015. Estimated abundance declined by 4-22% annually beginning in 2006 from a high of 133.4 million halibut. However, since 2013, abundance has appeared to level out. In contrast, biomass estimates were down in 2016 with a total of 338.8 million pounds (153,677 t) compared to 380 million pounds (172,365 t) in 2015.

In 2006-2007, Pacific halibut in the <40-cm size class dominated the overall catch (Fig. 4). In 2008, the 40-79 cm size class regained that position and has remained the dominant size class to present. In 2016, both the smallest and largest size classes decreased while the 40-79 cm size class increased. Size composition histograms (Fig. 5) illustrate the magnitude of the contribution that each size class has made to the estimated population in a given year. In 2016, the curve is clearly uni-modal, dominated by 40-50 cm halibut.

The age composition for Pacific halibut sampled in 2015 is shown in Table 2. Ages in the sample ranged from 2 to 20 years. The 4-year-olds (2011 year class) made up the largest percentage of the sample, at 33% of the total aged. The 2008 year class, which was dominant in the 2014 sample, comprised only about 6% of the sample in 2015. Fish from the older year classes have grown to a size where they are largely capable of avoiding survey trawl gear, which likely influences catches of these fish (Clark et al. 1997).

References

Clark, W. G. and Hare, S. H. 2007. Assessment of the Pacific halibut stock at the end of 2006. IPHC Report of Assessment and Research Activities 2006: 97-128.

Clark, W. G., St-Pierre, G., and Brown, E. S. 1997. Estimates of halibut abundance from NMFS trawl surveys. Int. Pac. Halibut Comm. Tech. Rep. 37.

Forsberg, J. E. 2001. Aging manual for Pacific halibut: procedures and methods used at the International Pacific Halibut Commission. Int. Pac. Halibut Comm. Tech. Rep. 46.

Forsberg, J., Sadorus, L., Logan, P., Kelleher, Z., Pedersen, C. 2016. Wire tagging Pacific halibut on NMFS trawl surveys: 2015 pilot study. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2015: 464-476.

Henry, E., Soderlund, E. Geernaert, T., Ranta, A. M., Kong, T., and Forsberg, J. E. 2017. 2016 IPHC fishery-independent setline survey. Int. Pac. Halibut Comm. Report of Assessment and Research Activities. IPHC-2016-RARA-26-R: 175-215.

International Pacific Halibut Commission. Unpub. 2016 NMFS trawl survey manual for IPHC personnel: Aleutian Islands and Bering Sea.

Stauffer, G. (compiler). 2004. NOAA Protocols for groundfish bottom trawl surveys of the nation's fishery resources. NOAA technical memorandum NMFS-F/SP0-65.

Webster, R. A. 2014. Construction of a density index for Area 4CDE. Int. Pac. Halibut Comm. Report of Assessment and Research Activities 2013: 261-288.

Table 1. Assigned maturity status of Pacific halibut that were retained for the biological sampling during the NMFS Bering Sea trawl survey in 2016. Females were assigned to one of four states: 1=immature, 2=ripening, 3=ripe/spawning, 4=spent/resting. Males were assigned to one of two states: 1=immature and 2=mature: U=unknown/could not be determined. Fish assigned to "Sex Unknown" were those selected for the tagging sample.

	Females					Males			Sex	
Length (cm)	1	2	3	4	Total	1	2	Total	Unknown	Grand Total
10-14									1	1
20-24						1		1		1
25-29	24				24	22	4	26	16	66
30-34	23				23	7	20	27	35	85
35-39	17				17		12	12	21	50
40-44	51				51	5	39	44	74	169
45-49	92				92	2	93	95	123	310
50-54	73				73		40	40	112	225
55-59	21				21		24	24	47	92
60-64	13				13		27	27	38	78
65-69	11				11		12	12	25	48
70-74	14				14		7	7	28	49
75-79	10				10		7	7	28	45
80-84	9	2			11		5	5	12	28
85-89	7				7		3	3	15	25
90-94	6	2			8		2	2	10	20
95-99	3				3		2	2	9	14
100-104	2				2				8	10
105-109	3	1			4				1	5
110-114									1	1
115-119	1				1				3	4
125-129									1	1
135-139		1			1					1
140-144									1	1
Grand Total	380	6	0	0	386	37	297	334	609	1,329

Table 2. Pacific halibut mean length (cm) and age (years) composition from sampled fish for the 2015 NMFS Bering Sea trawl survey standard grid.

Age (years)	Mean fork length (cm)	Std. dev. of fork length	No. of fish aged	Year class
2	28.2	2.95	9	2013
3	37.0	4.05	75	2012
4	39.9	3.95	174	2011
5	46.3	4.88	67	2010
6	53.4	5.18	25	2009
7	59.6	6.44	33	2008
8	64.2	6.59	17	2007
9	68.2	7.39	26	2006
10	73.9	8.64	23	2005
11	76.2	8.63	32	2004
12	81.7	13.51	28	2003
13	73.5	8.02	6	2002
14	78.3	8.14	4	2001
15	82.0	9.03	5	2000
16	86.5	9.19	2	1999
17	101.0	22.65	3	1998
18	86.0	n/a	1	1997
20	102.0	14.14	2	1995
Total	51.8	17.46	532	

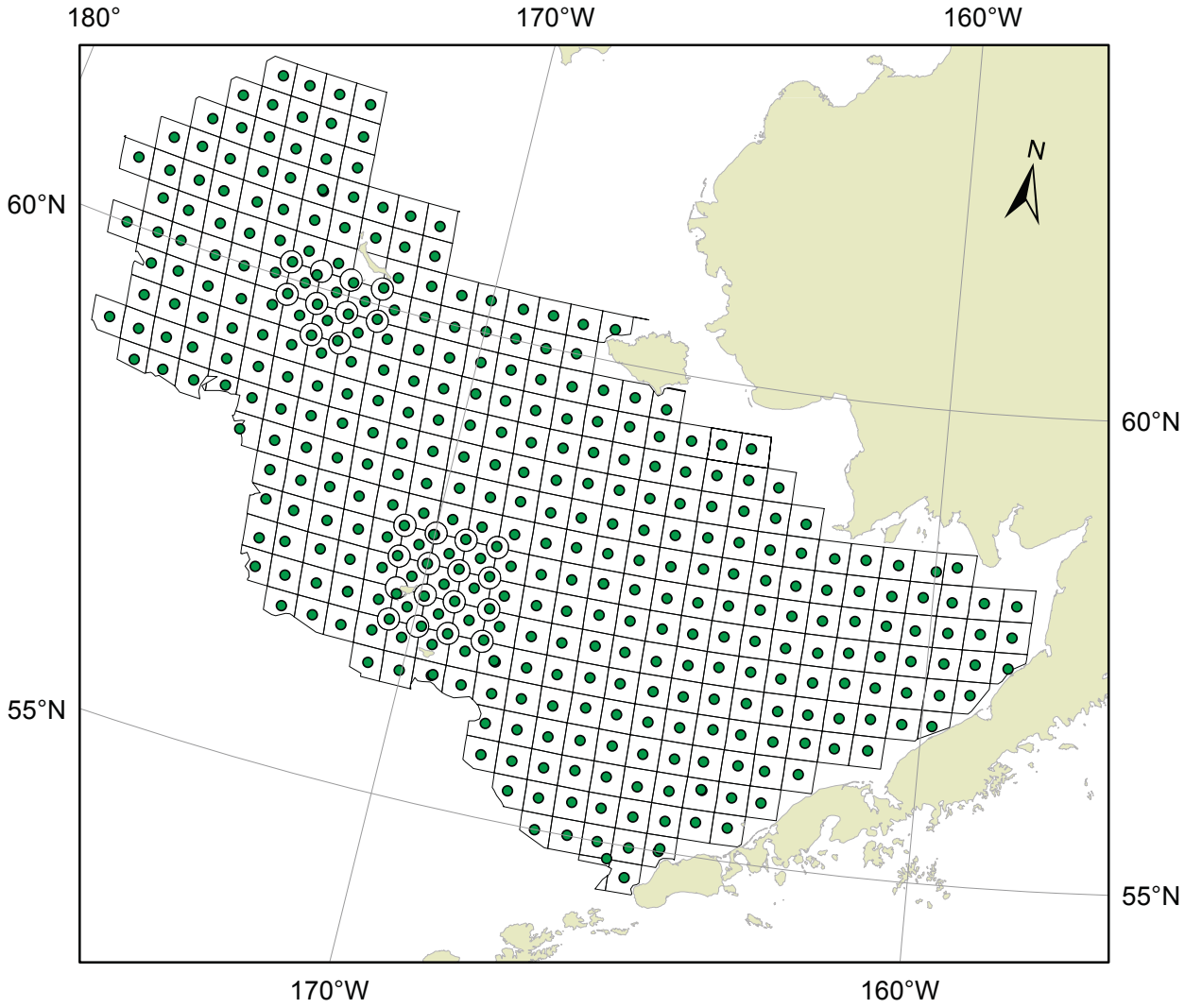

Figure 1. Sampling grid for the Eastern Bering Sea groundfish trawl survey. Each square represents a 20x20 nmi area and the dots represent the fishing station locations. Two vessels participated in the survey in 2016: *F/V Alaska Knight* and *F/V Vesteraalen*.

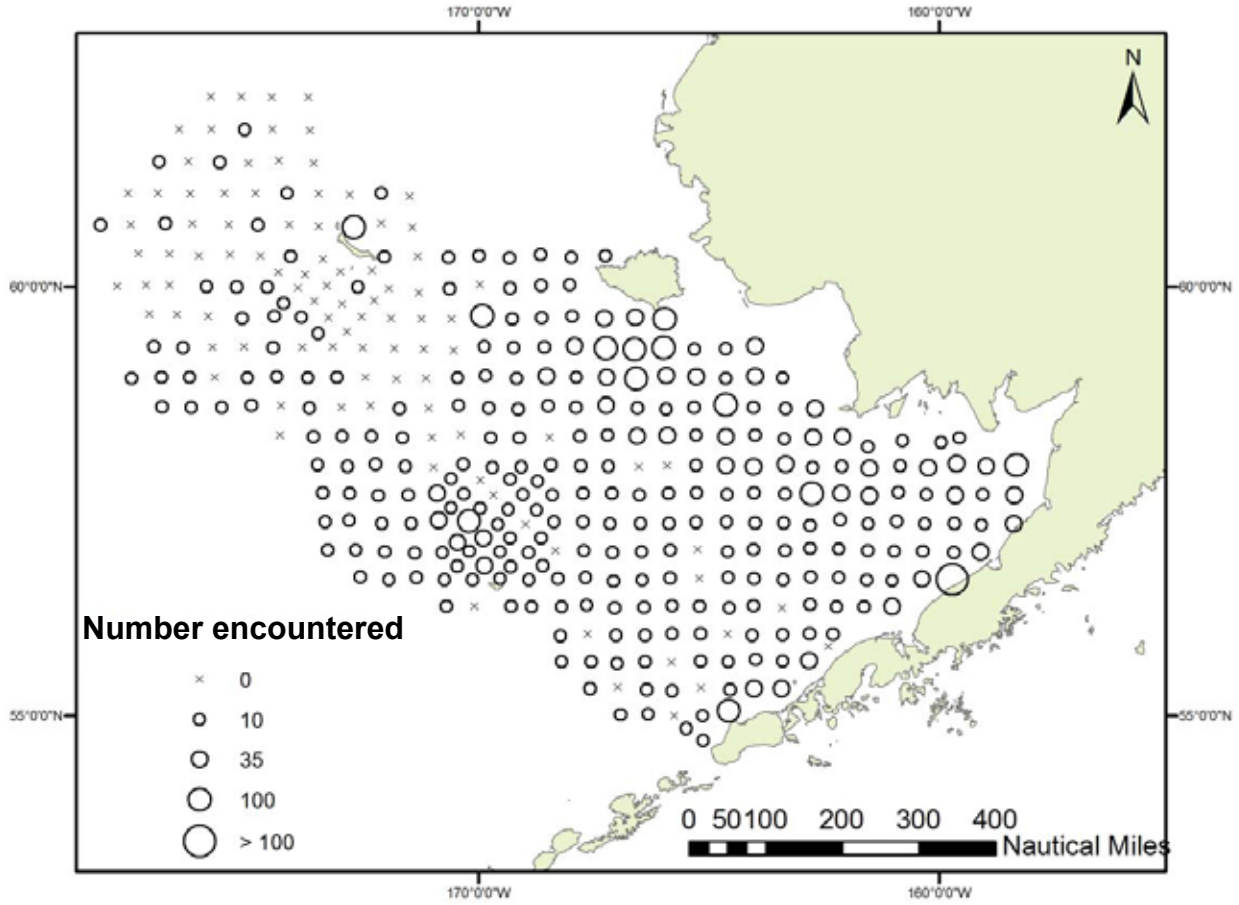

Figure 2. Number of Pacific halibut encountered at each survey station, by both vessels, during the 2016 NMFS Bering Sea trawl survey. Stations with an X indicate that no halibut were encountered.

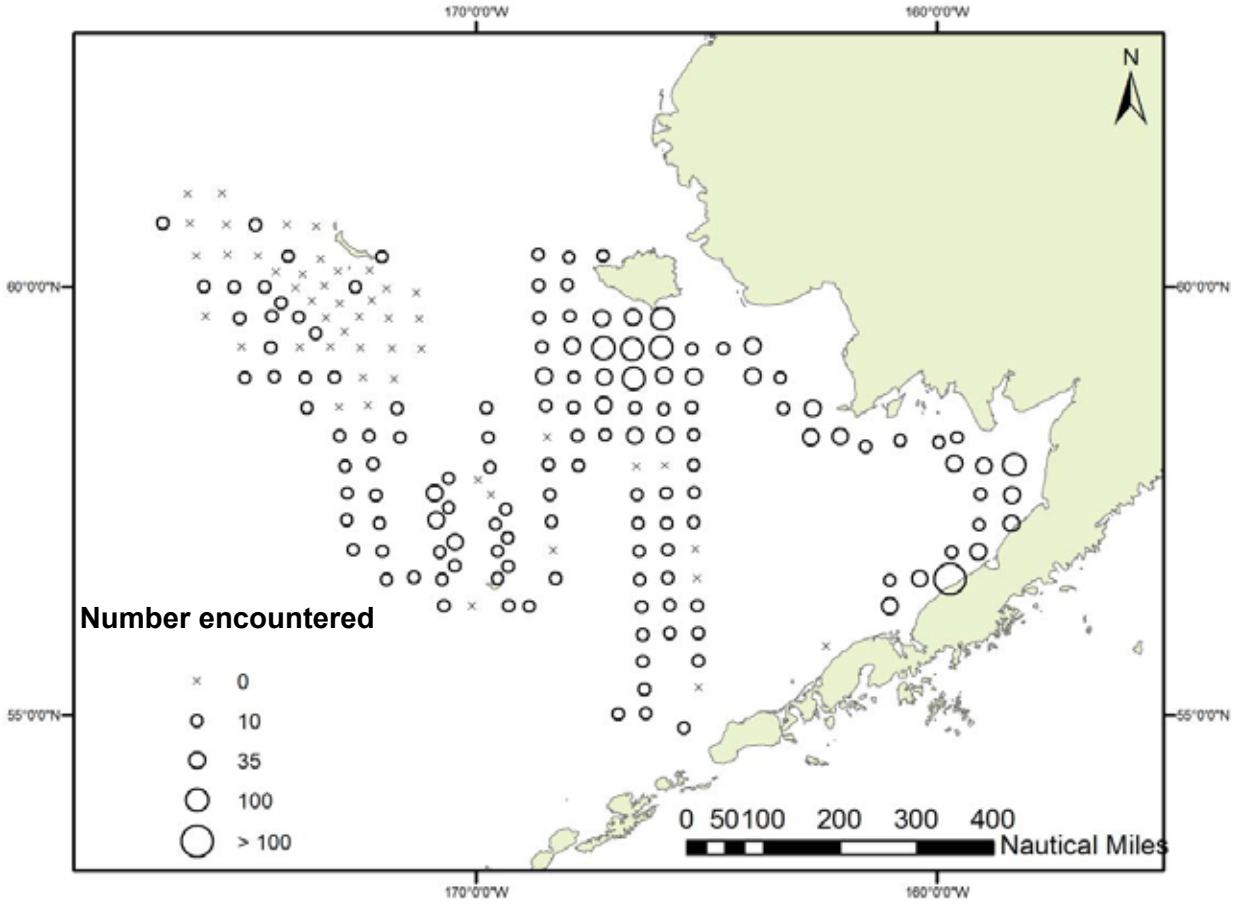

Figure 3. Number of Pacific halibut encountered by the *F/V Vesteraalen* during the 2016 NMFS Bering Sea trawl survey and subject to biological sampling or tagging. Stations with an X indicate that no Pacific halibut were encountered. Note that each station in the Bering Sea was occupied by only one vessel so while catches for each vessel were roughly representative of the area as a whole, sampling and tagging were not necessarily in proportion to abundance on a smaller spatial scale.

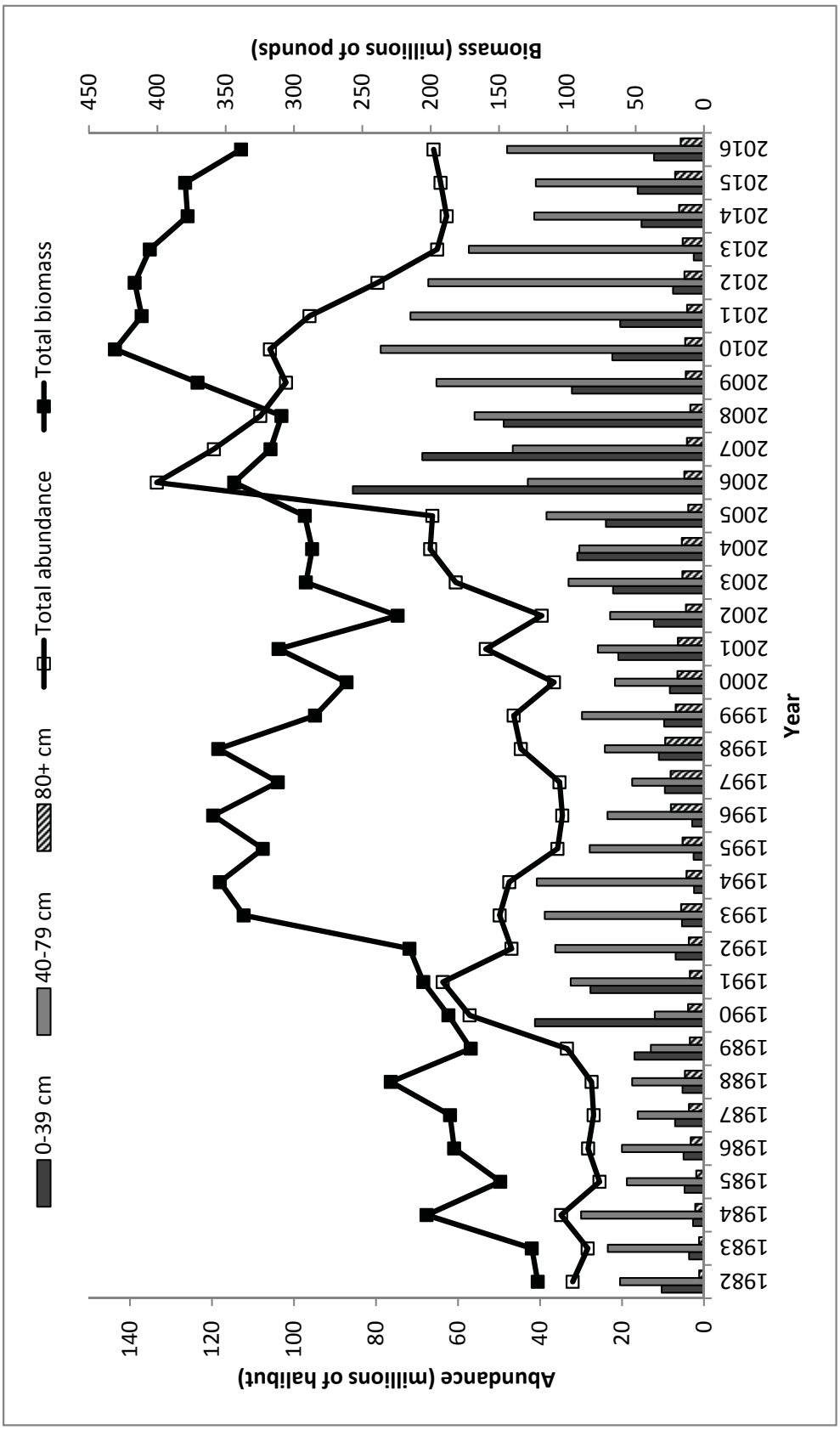

Figure 4. Estimated abundance (numbers of fish) of Pacific halibut by length category and total biomass (pounds) as estimated by the NMFS Bering Sea trawl survey data from 1982-2016, using swept-area estimates.

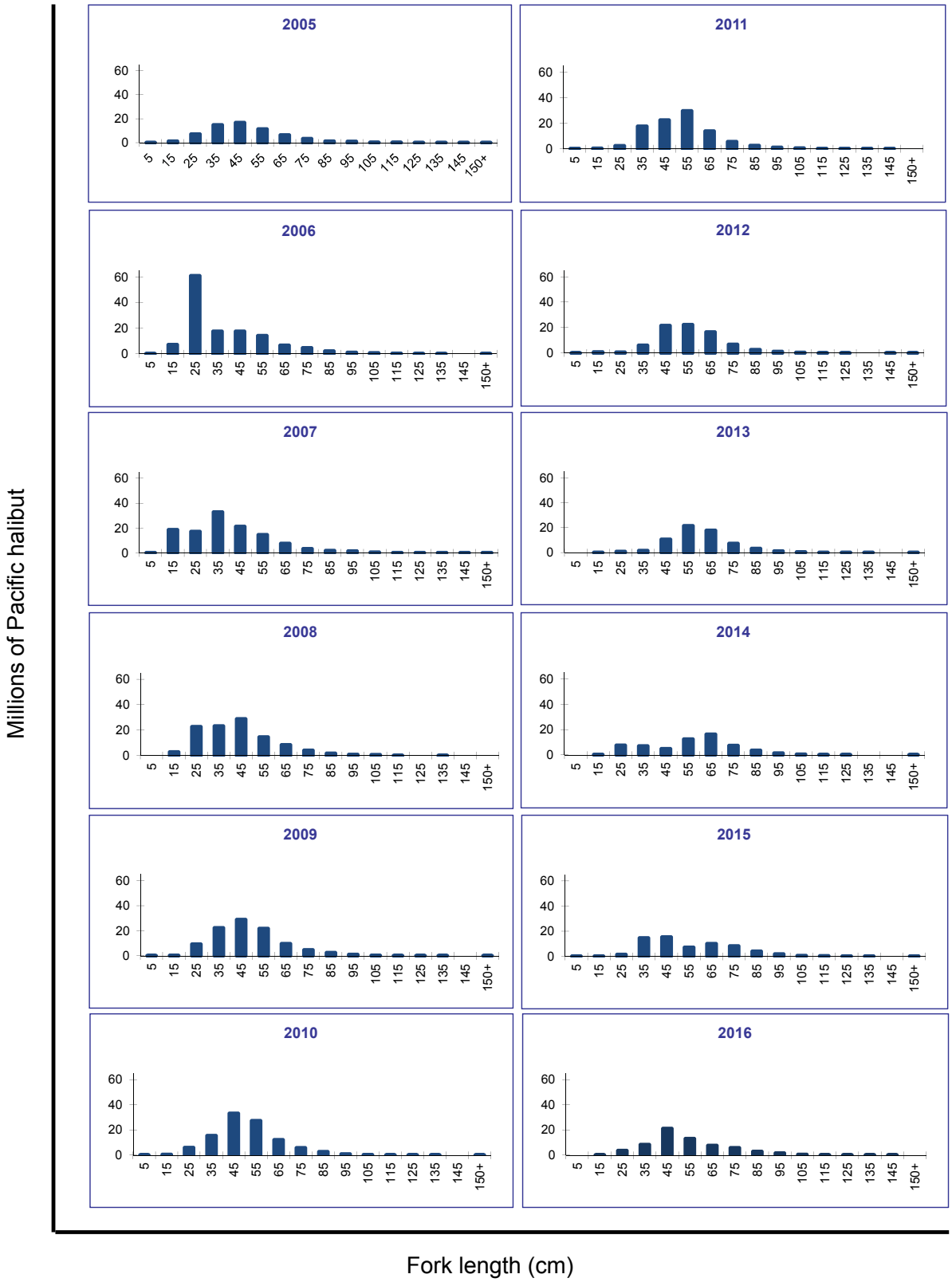

Figure 5. Pacific halibut abundance by 10-cm size bin in the Bering Sea as estimated by the NMFS Bering Sea trawl survey for the years 2004-2016. Note: Horizontal axis is fork length (cm) and the values showing on the graph represent the mid-point of each bin; vertical axis is millions of Pacific halibut.