NOAA Processed Report NMFS-NWFSC-PR-2020-03

https://doi.org/10.25923/p55a-1a22

The 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey:

Cruise Report SH-19-06

February 2020

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

NOAA Processed Report Series NMFS-NWFSC-PR

The Northwest Fisheries Science Center of NOAA's National Marine Fisheries Service uses the NOAA Processed Report NMFS-NWFSC-PR series to disseminate information only. Manuscripts have not been peer-reviewed and may be unedited. Documents within this series represent sound professional work, but do not constitute formal publications. They should only be footnoted as a source of information, and may not be cited as formal scientific literature. The data and any conclusions herein are provisional, and may be formally published elsewhere after appropriate review, augmentation, and editing.

NWFSC Processed Reports are available from the NOAA Institutional Repository, https://repository.library.noaa.gov.

Mention throughout this document of trade names or commercial companies is for identification purposes only and does not imply endorsement by the National Marine Fisheries Service, NOAA.

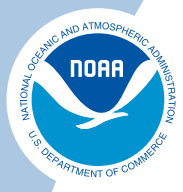
Cover images: (top) Pacific hake (*Merluccius productus*). Photograph by K. Barber, NMFS. (bottom) NOAA Ship *Bell M. Shimada* conducting intervessel calibration with NOAA Ship *Miller Freeman* off the Oregon coast, July 2010. Photograph by S. de Blois, NMFS/NWFSC.

Recommended citation:

(de Blois 2020)[1]

[1] de Blois, S. 2020. The 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey: Cruise Report SH-19-06. U.S. Department of Commerce, NOAA Processed Report NMFS-NWFSC-PR-2020-03.

https://doi.org/10.25923/p55a-1a22



NOAA FISHERIES

The 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey: Cruise Report SH-19-06

Steve de Blois

https://doi.org/10.25923/p55a-1a22

February 2020

Fishery Resource Analysis and Monitoring Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

Contents

Figures

Tables

Note: The tables in this report can also be downloaded from the report's NOAA Institutional Repository[1] record by clicking on the "Supporting Files" tab.

[1] https://repository.library.noaa.gov

Acknowledgments

Thanks go to the officers and crew of the NOAA Ship *Bell M. Shimada* and the Canadian F/V *Nordic Pearl* for their contribution to the successful completion of the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey. Thanks go also to all others who supported and helped make this survey a success, notably the personnel from the Northwest Fisheries Science Center's Fishery Resource Analysis and Monitoring, Conservation Biology, and Environmental and Fisheries Sciences Divisions, Fisheries and Oceans Canada's Groundfish and Applied Technology sections, and volunteers.

This survey was conducted under the authority of the following permits: California Department of Fish and Wildlife Scientific Collecting Permit SC-13614 and Memorandum of Understanding for Incidental Take, NMFS Biological Opinion WCR-2016-5783, NMFS Determination of Take Authorization under a Biological Opinion 16335-3R, NMFS West Coast Region Scientific Research Permit SRP-09-2019, NOAA National Marine Sanctuary Research Permit MULTI-2019-008, and Oregon Department of Fish and Wildlife 2019 – Scientific Taking Permit – Fish #22940.

Introduction

Pacific hake (*Merluccius productus*), hereafter "hake," is an important commercial marine fish found off the west coast of North America. Over the last ten years (2009–2018), coastwide annual harvests have averaged 285,434 metric tons (Berger et al. 2019), with U.S. and Canadian catches averaging 226,724 metric tons and 58,710 metric tons, respectively. In 2018, the coastwide catch was 410,443 metric tons. In addition to its commercial importance, hake is also a key trophic species and the most abundant groundfish in the California Current Large Marine Ecosystem (Sherman 1991). Because coastal hake have a prominent economic and ecological value, integrated acoustic-trawl (IAT) surveys have been used to assess the abundance, distribution, and biology of hake along the west coast of the U.S. and Canada (Fleischer et al. 2005). Beginning in 1977, the Alaska Fisheries Science Center (AFSC) conducted triennial IAT surveys in U.S. and Canadian waters, and in 1990 Fisheries and Oceans Canada (DFO) started conducting annual IAT surveys in Canadian waters. After the 2001 survey, responsibility for the U.S. portion of the IAT survey was transferred from the AFSC to the Northwest Fisheries Science Center (NWFSC) and the survey frequency was increased from triennial to biennial. In addition, since 1995 the U.S. and Canada have collaborated in assessing hake: the triennial IAT surveys of 1995, 1998, and 2001 were conducted jointly by the AFSC and DFO, and IAT surveys since 2003 have been conducted jointly by the NWFSC and DFO.

The results presented here are from the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey. This report provides a brief description of the methods used in the survey and summarizes the distribution, biological composition, and biomass of hake in U.S. and Canadian waters off the Pacific coast. It also summarizes results of acoustic system calibrations and secondary survey objectives.

Materials and Methods

Scientists from the Fishery Resource Analysis and Monitoring (FRAM) Division at the NWFSC and the Pacific region of DFO led the 2019 IAT survey aboard the NOAA Ship *Bell M. Shimada*—a 209-foot acoustically quieted Fisheries Survey Vessel—and the *Nordic Pearl*, a chartered 115-foot Canadian fishing vessel. Both vessels are stern trawlers equipped for fisheries research, while the *Shimada* is also equipped for oceanographic research.

The survey began south of Point Conception, California and proceeded north along the west coast of the United States and Canada, surveying Queen Charlotte Sound, Hecate Strait, Dixon Entrance, and the west side of Haida Gwaii (Figure 1). Hake aggregations were targeted for trawling along the entire survey area. The *Shimada* surveyed between 17 June and 17 August (Table 1) and the *Nordic Pearl* surveyed between 19 August and 13 September. Acoustic transects were oriented east-west (except for four transects in Dixon Entrance, which had a north-south orientation) and ranged from the 50-m isobath (or as close to shore as was safely navigable) to either the 1,500-m isobath or a location 35 nautical miles (nmi) west of the inshore waypoint, whichever was farther offshore. Transects were spaced 10 nmi apart through Transect 101 (just north of Vancouver Island), after which spacing increased to 20 nmi. Transects were traversed sequentially, usually in alternating directions. If hake were detected at the offshore end of a transect, the vessel proceeded west to the end of the hake sign and then beyond for an additional 0.5 nmi to ensure that the end of the aggregation was located. This protocol was in place to ensure that the interpolation algorithm used for calculating hake biomass performed correctly at the offshore ends of transects.

Acoustic Sampling

Equipment

Five Simrad split-beam transducers, operating at 18, 38, 70, 120, and 200 kHz, were mounted on the bottom of the *Shimada*'s retractable centerboard. To reduce interference from bubbles, the centerboard was extended to its maximum depth during the survey, thereby positioning the transducers at a depth of 9.15 m below the water surface. Acoustic data from all five transducers were collected with a Simrad EK60 scientific echosounder system coupled with an ER60 software system (version 2.4.3). A Simrad EK80 broadband scientific echosounder (version 1.12.2) collected acoustic data from all five transducers during the second of two calibrations of the acoustic systems.

The *Shimada* was equipped with a Teledyne RD Instruments Ocean Surveyor 75-kHz Acoustic Doppler Current Profiler (ADCP) system and a Simrad ME70 scientific multibeam echosounder system, but the ME70 system was not used because of interference with the other acoustic systems. A Simrad K-Sync unit was used to synchronize pulse sequences from the EK60 and ADCP acoustic instruments.

Acoustic data on the *Nordic Pearl* were collected with a Simrad EK60 scientific echosounder system coupled with an ER60 software system (version 2.4.3). Two Simrad split-beam transducers, operating at 38 and 120 kHz, were mounted on a transducer pod located roughly 1.5 m starboard of the keel.

Calibration

The *Shimada*'s acoustic system was calibrated in the field before and after the survey; the *Nordic Pearl*'s acoustic system was calibrated before and during the survey. Calibration locations were chosen based on survey logistics and selecting sites where the water beneath the ship was sufficiently deep (to avoid echo contamination from multipath effects) and where the water column was, as much as possible, devoid of fish and other marine life. Offshore of Newport, Oregon the *Shimada* drifted and used dynamic positioning; offshore of Monterey, California and in Elliott Bay, Washington the *Shimada* was anchored from the bow. The *Nordic Pearl* anchored from the bow as well. The calibration procedure involved suspending a metal sphere with known backscattering cross-sections below the transducers and measuring the acoustic return following standard procedures (Simmonds and MacLennan 2005, Demer et al 2015). On both the *Shimada* and the *Nordic Pearl*, a 38.1-mm tungsten carbide sphere with 6% cobalt binder was used for all transducers. Target strength and echo integration data were collected to calculate echosounder gain parameters to ensure the quality of system performance. On-axis and beam pattern data were recorded during the calibrations.

Operations

The *Shimada* maintained a vessel speed of approximately 11 knots (kn) during acoustic operations along each transect and up to 12 kn on cross-transects. The *Nordic Pearl* maintained a vessel speed of around 9 kn during survey operations. Running of acoustic transects occurred only between sunrise and sunset (i.e., roughly from 06:00 to 21:00 PDT, about 15 hours per day) when hake formed identifiable midwater layers, although acoustic data were collected day and night. Likewise, ADCP data were also collected day and night.

Acoustic data were collected from the transducer faces to a maximum depth of approximately 750 m. Raw acoustic backscatter (ER60 .raw) data files were logged from all five frequencies. Acousticians used the raw files for live viewing and for scrutinizing on laptop PCs with Myriax Echoview software (version 9.0.279). Event log markers and other marks, including at-sea judgments of hake backscattering layers, were made on the live-viewed files. While all five EK60 frequencies could be used for at-sea judgements, data from only the 38-kHz echosounder (the primary frequency used for generating biomass estimates) were post-processed for hake using Echoview, and results presented in this document are based on these data. (Data from the 120-kHz echosounder are being post-processed for euphausiids.)

Background noise was recorded in passive mode at frequent intervals either before the surveying of transects started in the morning or during cross-transects conducted offshore at depths greater than 1,500 m. These recordings were done to ensure the quality of the acoustic data and the consistency of system performance throughout the survey.

Analysis

Adult hake (age-2+) biomass and variability were estimated from survey data using kriging, one of several geostatistical numerical and mathematical techniques used to analyze observations that are correlated in space (Journel and Huijbregts 1978). Kriging—a local estimator used to interpolate a spatially distributed quantity in an unobserved location—has been considered suitable for estimating fish abundance and precision parameters (Rivoirard et al. 2000) and has been used to estimate the abundance and variance of fish stocks surveyed using acoustic techniques (Rivoirard et al. 2000, Simmonds and MacLenann 2005).

Biological Sampling

Equipment

Daytime trawling on fish sign observed by the *Shimada* was performed with an Aleutian wing trawl 24/20 (AWT). This net had a vertical opening that averaged 26 m (range: 17–36 m) and a headrope and footrope of 101.7 m each. A 1¼-inch (32-mm) codend liner was used. The AWT was deployed with a pair of 4-m^2, 884.5-kg "Fishbuster" trawl doors, 82.3-m legs, and 750-lb chain ("Tom") weights on each side. Rigging between the trawl doors and the headrope and footrope consisted of synthetic 18-mm TS-II rope. A Simrad FS70 third-wire trawl sonar was attached to an AWT headrope kite to monitor depth, net opening, and water temperature, and to gauge approximately the catch quantity. A Samsung Galaxy Tab A 9.7" (SM-T550), running an app created in-house with Android Developer, was used for the first time this survey to record net mensuration details.

Daytime trawling on fish sign observed by the *Nordic Pearl* was performed with an RS 250/550/14 midwater trawl (Cantrawl Pacific Fishing Services Ltd.) rigged with 950-kg Thyboron Type-2 doors and 200-pound chain weights on each side. This trawl had 76.2-m long foot and head ropes with double side wings (three-point tow connection) along a 111.25-m side panel rope. The codend liner had a mesh of ¼ inch (6 mm). A Scanmar ScanBas trawl sonar was attached to the Cantrawl headrope to monitor and guide the fishing process for all trawls.

To provide additional biological ground truthing (i.e., provide information on the biological composition of multiple scattering layers in the water column), the AWT was deployed on all but the last four trawls with a SpyTec Mobius camera and light system mounted to the top panel of the intermediate approximately 20 m forward of the codend. The camera faced aft and along the net toward the codend. Three custom pressure housings (made by Sexton Corporation) were mounted to a rigid ultra-high-molecular-weight polyethylene (UHMWPE) board. Two of the pressure housings held LED lights while the third held the camera. The housings with enclosed batteries used a pressure switch to activate lights and camera. The camera was programmed to start recording when external power was applied. Video data stored on a 32GB micro SD card in the camera were transferred to external storage shortly after each trawl was completed. Time, temperature, and pressure information collected from a Sea-Bird Electronics, Inc. SBE 39 temperature and pressure recorder clipped near the camera was overlaid onto the video files using a program written in-house with Python.

Files were spliced together and trimmed to remove video prior to the lights switching on underwater and directly after the lights switched off. Review of the video was completed as soon as possible following a trawl and notes were recorded onto a spreadsheet.

Similarly, the Cantrawl on the *Nordic Pearl* was equipped with a digital video camera system mounted inside the net. This system had, however, a significantly different layout than the camera system used on the *Shimada*, and was used to assess the catch effectiveness of the net and behavior of organisms before they reached the trawl codend. This system consisted of a separate camera pressure housing and LED light pressure housing mounted in stainless steel frames tied directly to the inside of the net's top section. The lights were connected to an external battery pack housed in its own pressure cylinder. The frames were positioned at approximately 29 meters ahead of the codend section (which was 18 m long). The camera was facing down and toward the aft of the net, at an angle of approximately 30°. The light source was placed 1.5 m aft of the camera and was aimed directly downward, toward the bottom of the net. The camera used was a GoPro HERO4, while the pressure housing and lights were manufactured by A.G.O. Environmental Electronics Ltd.

During the final four trawls of the U.S. portion of the survey, a stereo camera system was deployed for field testing. The camera system had two pressure housings, one for the cameras and one for the battery, as well as four smaller housings for LED lights that were attached to an aluminum frame. Two Jai 800GE 4/3" progressive scan cameras (one color Bayer mosaic and one monochrome) were controlled by an ADL QM67PC single-board computer via control boards. Four lights, each using four BridgeLux LEDS and a TaskLED driver, were set in strobed mode. The battery was a set of three nickel metal hydride (NiMH) cells capable of being removed and charged. The frame was attached to the net on the outside, 8 m forward of the codend, looking from port to starboard. The data were stored on a 120GB solid state drive (SSD) and transferred after every trawl via an Ethernet connection.

To verify the identity of acoustic targets suspected to be euphausiids (Euphausiacea) and/or lanternfish (Myctophidae) and to obtain specimens for species identification and length, a Methot trawl was deployed during daytime hours. The Methot consisted of a square metal frame (inner dimensions of 2.4 × 2.4 m) to which an outer protective net (2.4 × 2.4 m × 44 ft, with a 2-in mesh) and an inner net (1.4 × 1.4 m × 43 ft, with a ⅛-in mesh) were attached. Samples were collected in a two-piece PVC collection bucket attached to the tail end of the inner net. To stabilize the Methot trawl during fishing, a 2.5-m wide V-shaped metal net depressor fin with a 75-lb ballast weight was attached. A Simrad integrated trawl instrumentation (ITI) sensor was attached to the frame to monitor depth in real time while fishing.

An electronic, 60-kg capacity Marel M1100 PL4200 motion-compensating scale was used to weigh sorted portions of the catch to the nearest 0.05 kg. A 15-kg capacity Marel M1100 PL2060 motion-compensating scale was used to determine weights of individual fish specimens to the nearest 0.002 kg. Individual fish lengths (fork length) were determined to the nearest centimeter with a Scantrol FM100 FishMeter board.

The *Shimada*'s flow-through system was used to collect water for analysis of the presence, distribution, and identification of harmful algal bloom (HAB) species and the toxins they produce. Niskin bottle water collections were taken at CTD (conductivity-temperature-depth) stations; water extracted from the Niskin bottles was filtered in support of eDNA work. A 0.5-m vertical ring net with flowmeter and mesh size of 202 µm was used to conduct vertical zooplankton tows at predetermined sites.

Operations

Daytime trawling was used to classify observed backscatter layers to species and size composition and to collect specimens of hake and other organisms. The number and locations of trawls were not pre-determined—other than an allowance for an expected total number of trawls by area based on available survey time—but depended on the occurrence and pattern of backscattering layers observed at the time of the survey. Coverage by trawling was adaptive: highest priority was given to sampling distinct layers of intense backscatter that were indicative of high densities of hake. When possible, trawls were conducted at more than one location along any single, extensive, and continuous aggregation of hake, or within the same area where vertically discrete backscattering layers appeared.

Prior to commencing trawl operations, NWFSC marine mammal protocols were followed on the *Shimada* to ascertain that no marine mammals were within 500 m for ten minutes prior to deploying gear, and that no killer whales (*Orcinus orca*) were observed at any time, regardless of distance from the ship. During trawl operations, trawling speed averaged about three kn (up to two kn for the Methot trawl); observing for marine mammals and any seabird gear strike was maintained. Individual trawl durations varied, lasting only long enough to ensure that an adequate sample (i.e., a minimum of approximately 350 hake) was obtained. The scientist overseeing trawl operations determined the trawl duration based on the quantity of fish and other organisms that the trawl sonar observed entering the net.

Trawl catches on the *Shimada* were sorted and weighed completely. CLAMS (Catch Logger for Acoustic Midwater Surveys), a program developed by the AFSC, was used for recording catch parameters. Total weights and numbers were determined for most species; gelatinous invertebrates such as jellyfish and salps often could not be counted because trawling frequently broke them apart. Hake were subsampled to determine length composition by sex (about 300 random samples per trawl) and to collect roughly 50 "enhanced" samples per trawl. When fewer than 350 hake were caught, they were sampled completely. The "enhanced" samples included collecting individual weights, lengths, sex, sexual maturity as determined by visual inspection of gonads, and otoliths for all fish in the sample. Otoliths were preserved in 50% ethanol for subsequent age determination. Additional measures for special projects were also taken on the "enhanced" sample fish. Hake ovaries were collected by size bins for histology and RNA analysis, with the ovaries preserved in 10% neutral-buffered formalin and the ovary RNA samples preserved in RNA*later*, an aqueous tissue storage reagent. The liver of the hake selected for ovary removal was also taken, with one piece frozen and another piece preserved in RNA*later*. Ten stomachs per trawl were taken, of which five were preserved in 10% neutral-buffered formalin for later analysis back on shore, while the contents of the other five were identified to the top three species and

recorded without delay. Finally, hake fin clips were collected for genetic analysis from 48 of the "enhanced" sample hake. With regards to nonhake species, lengths were taken from all rockfish, squid, and any species that was dominant in the catch composition. Widow rockfish (*Sebastes entomelas*) were sampled for individual weights, lengths, sex, sexual maturity, and otoliths, with ovaries being taken based on size bins. Lastly, a variety of species were frozen whole for a mix of special project requests.

Zooplankton sampling with a vertical ring net was conducted along Transects 2 (Point Conception), 25 (Bodega Bay), 41 (Trinidad Head), and 63 (north of the Newport Hydroline). Six stations per transect were completed at bottom depths of 60 m, 150 m, 300 m, 500 m, 1,000 m, and 1,500 m. The net was towed vertically while the *Shimada* held station. A target depth of 100 m was used when bottom depths were greater than 100 m; when bottom depths were shallower than 100 m, a target depth of 2–5 m off bottom was used. Zooplankton samples were stored in formalin to be analyzed back on land.

Oceanographic Sampling

Equipment

Vertical profiles of temperature and salinity data were collected on the *Shimada* using a rosette-mounted Sea-Bird SBE 911plus CTD system. In conjunction with the CTD casts, vertical profiles of dissolved oxygen (DO) were collected using a Sea-Bird SBE 43 DO sensor that was attached to the SBE 911plus CTD. Additional oceanographic data were collected by attaching Sea-Bird SBE 39 temperature and pressure recorders to the AWT headrope kite and underwater camera system during trawls, and—during the last leg of the survey— by deploying an Oceanscience UnderwayCTD (uCTD) while the vessel was underway. Sea surface temperature and salinity data were collected using a Sea-Bird SBE probe located below the vessel's waterline in the *Shimada*'s flow-through system. On the *Nordic Pearl*, profiles of temperature, salinity, and dissolved oxygen were collected on all trawls from a net-mounted CTD (RBRconcerto^3 standard logger) that was affixed to the starboard trawl ribline, adjacent to the trawl camera.

Operations

Physical oceanographic sampling was conducted day and night on the *Shimada*. CTD casts were performed at night at predetermined locations, in conjunction with zooplankton sampling stations, and when the acoustic system was calibrated. Underway CTD casts were conducted at predetermined stations during daytime while the ship was collecting acoustic data, but only if sea conditions were favorable for safely deploying the uCTD probe. When deploying uCTDs, the *Shimada* slowed down to about 6 kn. The *Shimada*'s Scientific Computer System (SCS) collected sea surface data (e.g., temperature and salinity) continuously day and night throughout the entire survey.

Results

Acoustic System Calibration

A calibration of the *Shimada*'s EK60 acoustic system was attempted on June 13 offshore of Newport, but the site had to be abandoned when wind and currents made positioning the calibration sphere within the system's acoustic beam infeasible. The *Shimada* steamed south and attempted another calibration offshore of Monterey on June 16. Results from the Monterey calibration and a second one conducted on August 20 in Elliott Bay (Table 2) were within expected levels based on factory settings and results from previous calibrations. The EK80 system was calibrated once, in Elliott Bay; its calibration also was successful. The *Nordic Pearl's* acoustic system was calibrated on August 17–18 in Saanich Inlet, Vancouver Island, and September 12 in Tasu Sound, Moresby Island. Results of the calibrations were also within expected levels based on factory settings and results from previous calibrations.

Acoustic Sampling and Pacific Hake Distribution

The *Shimada* collected acoustic data from 78 transects (Table 3) between 34.4°N and 48.6°N for a linear distance of 3,199 nmi; the *Nordic Pearl* collected acoustic data from 35 transects (Table 4) between 48.7°N and 54.8°N for a linear distance of 1,305 nmi. The *Shimada* dropped eight transects, the *Nordic Pearl* four.

Thirteen transects in U.S. waters were extended further west to map the offshore extent of hake sign; total linear distance of the extensions was slightly over 82 nmi. Two of the extended transects were off the coast of Oregon; the rest were off the coast of Northern California between Crescent City and San Francisco. The *Nordic Pearl* shortened four transects (94–98) off the northern end of Vancouver Island.

Adult hake were observed on 83 transects, ranging from Transect 9, north of Morro Bay, California, to Transect 101, north of Vancouver Island (Figure 2). Off the U.S. coast, hake concentrations between roughly 36°N and 39°N were comparatively light. North of 39°N, aggregations of observed hake sign became more consistent and extensive; areas of strong hake sign were observed between Crescent City, California and Newport. North of Newport, hake sign diminished but still remained fairly consistent; relatively high amounts were observed south of Astoria, Oregon and along the northern half of Washington State. In Canadian waters, although only modest aggregations of hake were observed along much of Vancouver Island and no hake were observed further north, higher concentrations of hake were observed near the northwest tip of the island and west of Barkley Sound.

Biological Sampling

The *Shimada* successfully conducted 67 midwater trawls during the survey and the *Nordic Pearl* conducted 22 (Figure 3, Tables 5 and 6). The *Shimada* also conducted four open-codend trawls at the end of the survey to test a new stereo camera system. Average trawl duration on the *Shimada* was 19.2 minutes (range: 1.1–45.4). Average trawl depth was 278 m

(range: 96–510); 89% of trawls (n = 63) were conducted between 101 and 400 m. Almost half of all trawls conducted on the *Shimada* (49%, n = 35) were within 50 m of the bottom, while 23% (n = 16) were greater than 500 m off bottom. On the *Nordic Pearl*, average trawl duration and target depth were 16.2 minutes (range: 3.8–29.3) and 200 m (range: 82–414), respectively; over half of the trawls (55%) were between 101 and 200 m. On the *Shimada*, because marine mammals were within 500 m of the vessel, one trawl was aborted before deployment of gear and four were aborted after gear deployment. Two other trawls were aborted because of gear issues, and one trawl was aborted because of severe weather. No trawls were aborted on the *Nordic Pearl*.

Of the 67 trawls that the *Shimada* conducted with a closed codend, 63 (94%) caught hake, including one trawl (14) that caught roughly 0.3 kg (n = 265) of young-of-the-year (i.e., age-0) hake. Overall, hake catch weights ranged from 0.3 kg to 1,561.6 kg, with an average of 235 kg; non-hake catch weights ranged from 0.1 kg to 417.0 kg, with an average of 27 kg. Of the 22 trawls that the *Nordic Pearl* conducted, 13 (59%) caught hake. Hake catch weights ranged from 1.0 kg to over 9,000 kg; other than three trawls that caught in excess of 3,500 kg and one trawl that caught just under 500 kg of hake, most trawls (82%) caught either less than 200 kg of hake or none at all.

The *Shimada* conducted six successful Methot trawls (Table 7), all of which were in U.S. waters. Average duration was 17.4 minutes (range: 6.2–24.9) and average gear depth was 160 m (range: 29–355).

Hake was the dominant species caught in the 66 trawls that the *Shimada* conducted in U.S. waters (Table 8), accounting for almost 88% of catch composition by weight and approximately 53% by number. Ninety other species were caught, but none accounted for more than roughly 2% by weight. Across all trawls, besides hake, relatively large numbers of northern anchovy (*Engraulis mordax*) and several species of lanternfish (Myctophidae) were caught. In the one trawl that the *Shimada* conducted in Canadian waters (Table 9), the catch consisted essentially of a mix of hake and walleye pollock (*Gadus chalcogrammus*). Catch composition of the trawls the *Nordic Pearl* conducted in Canadian waters (Table 10) consisted primarily of hake (75% of total catch by weight). Three species of rockfish accounted for the next 15% of total catch composition by weight. Relatively large numbers of Pacific herring (*Clupea pallasi*) were also caught.

Between the *Shimada* and the *Nordic Pearl*, more than 18,500 hake were measured for length and 3,265 pairs of hake otoliths were collected (Tables 11 and 12). Over 2,440 hake fin clips were collected on the *Shimada* as well. On the *Nordic Pearl*, in addition to the hake stomachs that were examined, 30 stomachs from six trawls were collected and frozen for future lab analysis. Raw length frequency distributions (Figure 4) were characterized by U.S. hake displaying smaller modes at 22 cm (age-1 hake) and 32 cm (age-2 hake), with a much larger mode at 42 cm (primarily age-3 and age-5 hake). A few age-0 hake at 5–10 cm were observed, as well as hake larger than 55 cm. Hake in Canada consisted primarily of fish between 40 and 60 cm, with a mode at 48 cm. Excluding age-0 fish, hake specimens collected during the survey ranged in age from 1 to 21 years (Figure 5); age-5 (2014 year-class) and age-3 (2016 year-class) hake were the two most dominant age classes observed, followed by age-9 hake (2010 year class). Age-1 and age-2 hake formed smaller modes.

Pacific Hake Abundance Estimate

The 2019 biomass estimate of adult hake off the U.S. and Canada west coast totaled 1.723 million metric tons (Mt; Figure 6), with approximately 89% (1.531 Mt) of observed biomass located in U.S. waters. The 2019 estimate was roughly 20% larger than the average biomass estimate for all surveys conducted since 1995 (1.723 vs. 1.431 Mt), and represented an increase of 0.3 Mt over the 2017 biomass estimate. Age-3 and age-5 hake contributed most to the 2019 biomass estimate—combining for almost 57%—followed by age-9 hake (Figure 7).

Oceanographic Sampling

Two hundred ninety-five (295) CTD temperature and salinity profiles were collected by the *Shimada* at selected locations along the line transects and at acoustic system calibration sites (Figure 8); 22 uCTD profiles were successfully collected (one failed). Additional temperature profiles were collected from 146 successful SBE 39 casts (68 with the AWT headrope kite, 67 with the AWT camera system, six with the Methot trawl, and five with the AWT stereo camera). Also collected were zooplankton samples at 24 stations, 340 HAB samples, and 1,930 eDNA samples. The *Nordic Pearl* collected CTD profiles at calibration sites and at all trawl stations.

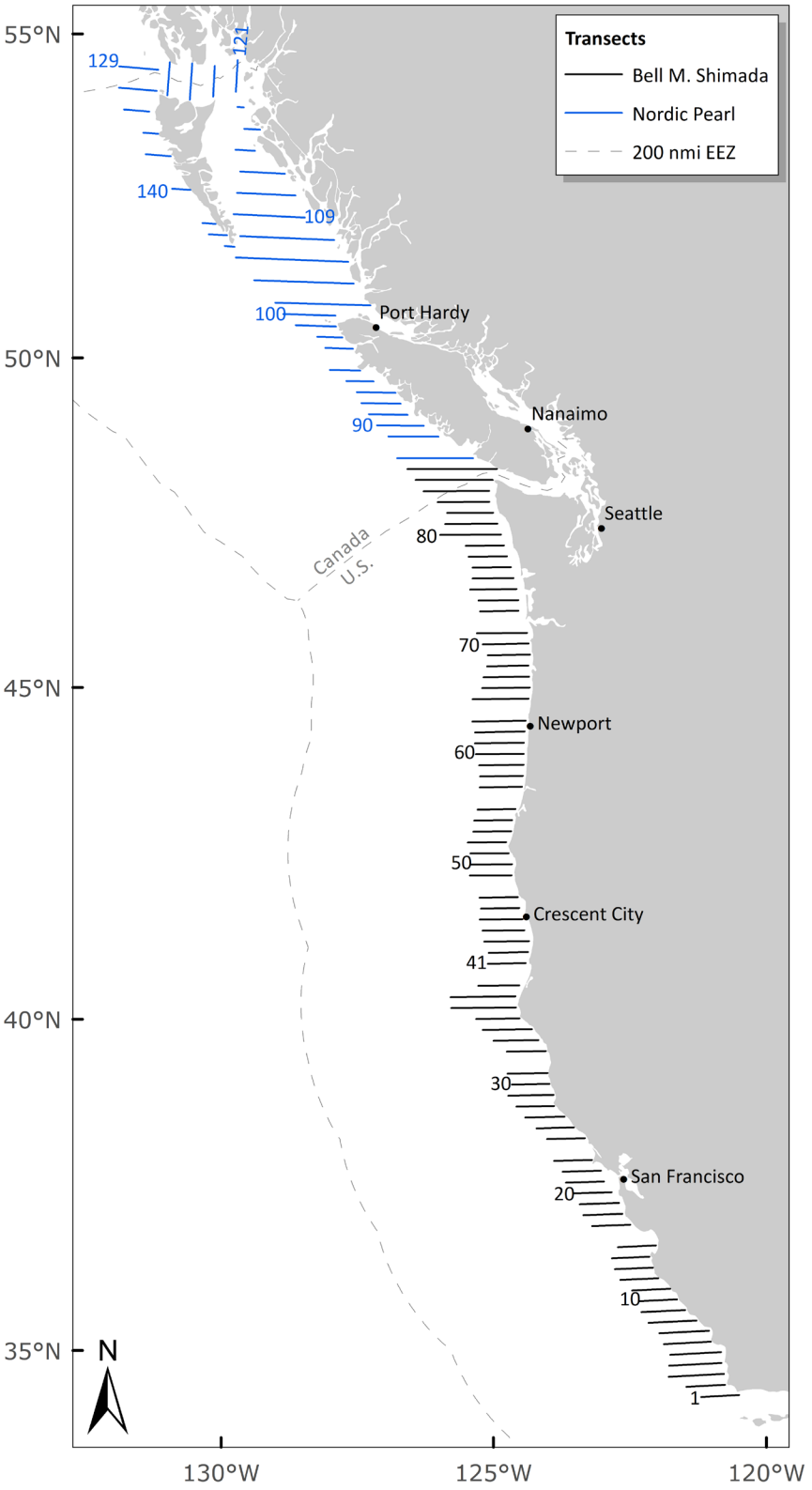


Figure 1. Survey track design used during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

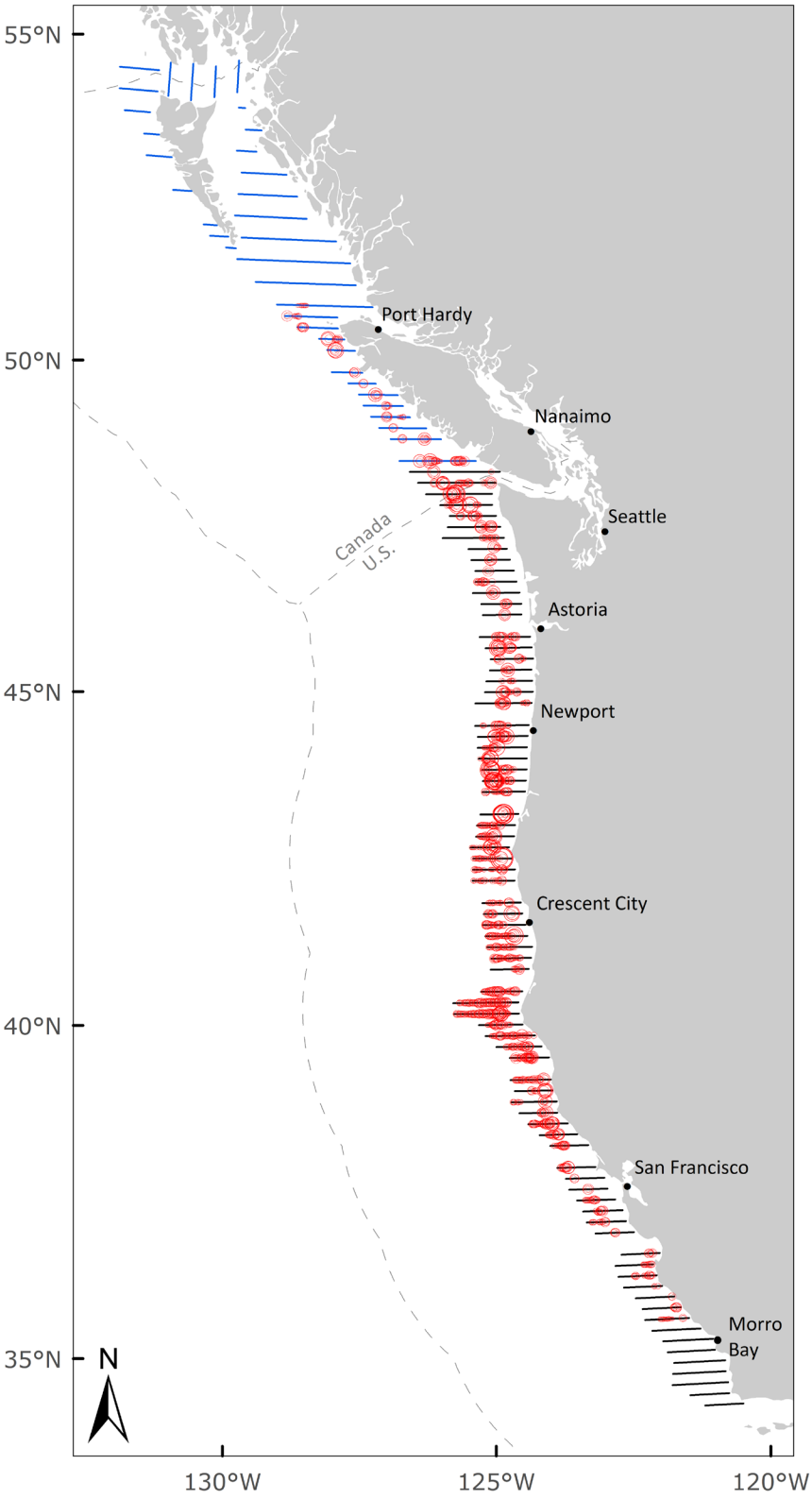


Figure 2. Acoustic area backscattering attributed to adult (age-2+) Pacific hake along transects completed during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

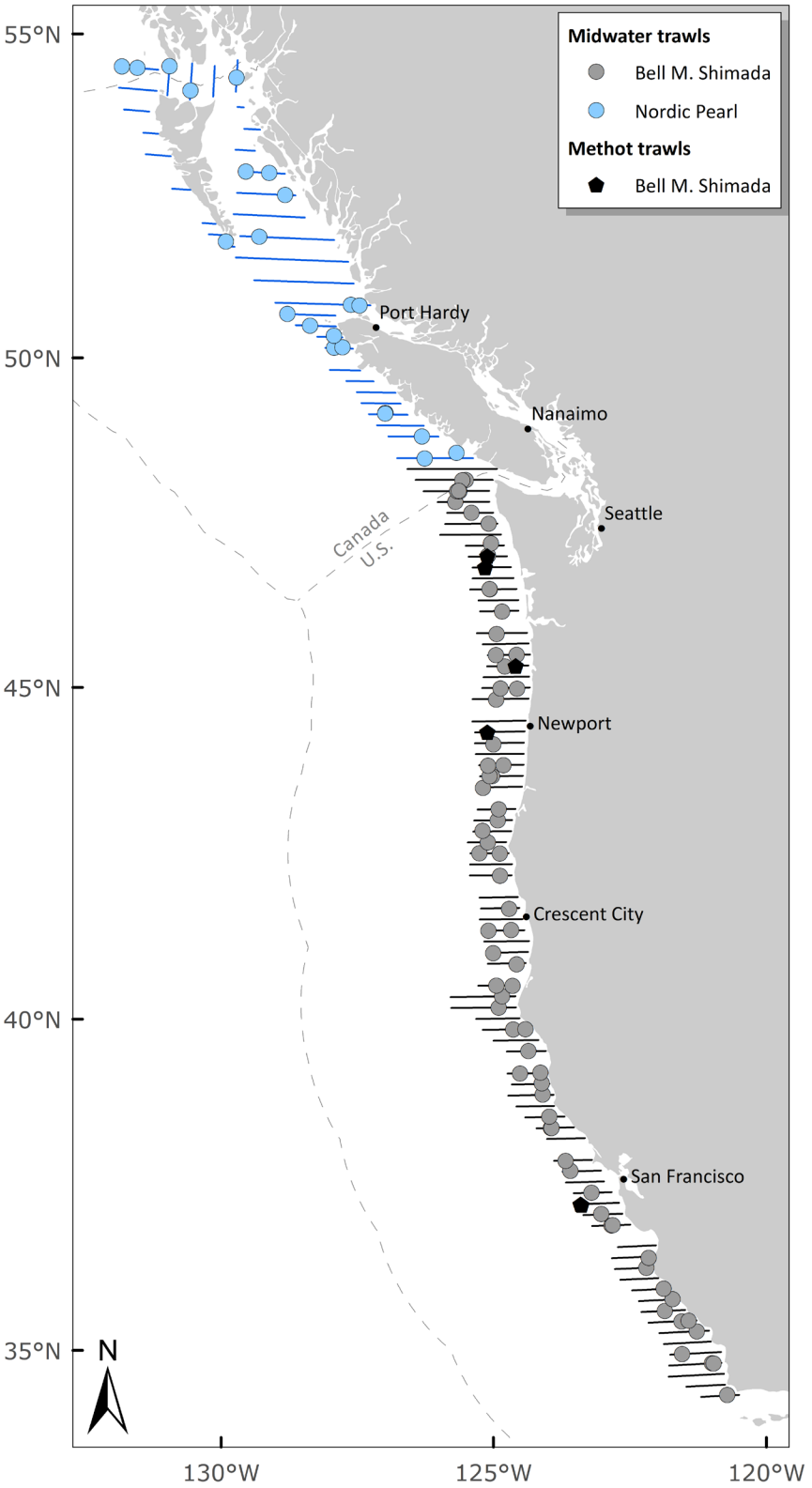


Figure 3. Acoustic transect lines and locations of midwater trawls and Methot trawls conducted during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

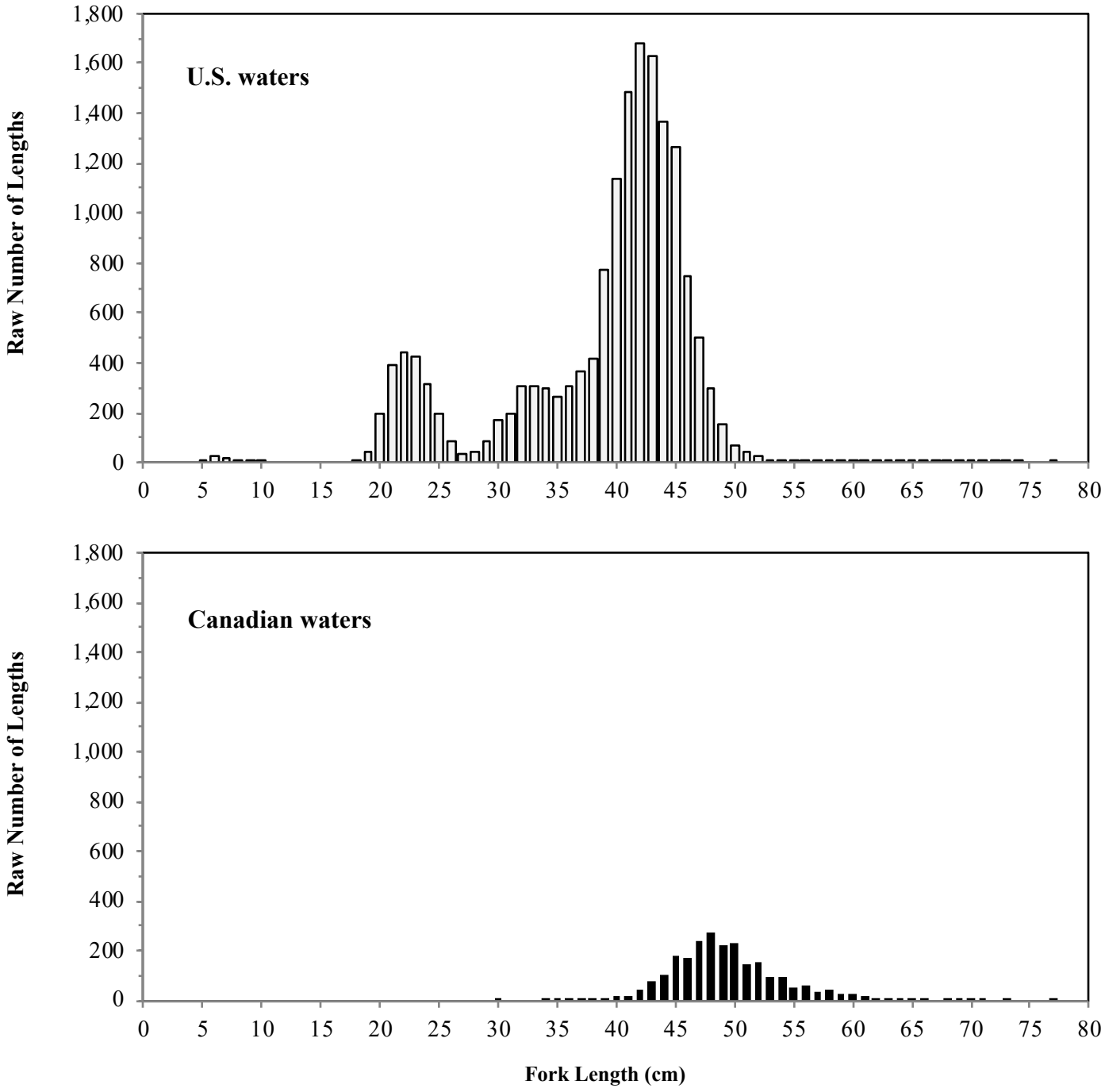


Figure 4. Raw length frequency distributions of Pacific hake from specimens measured during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

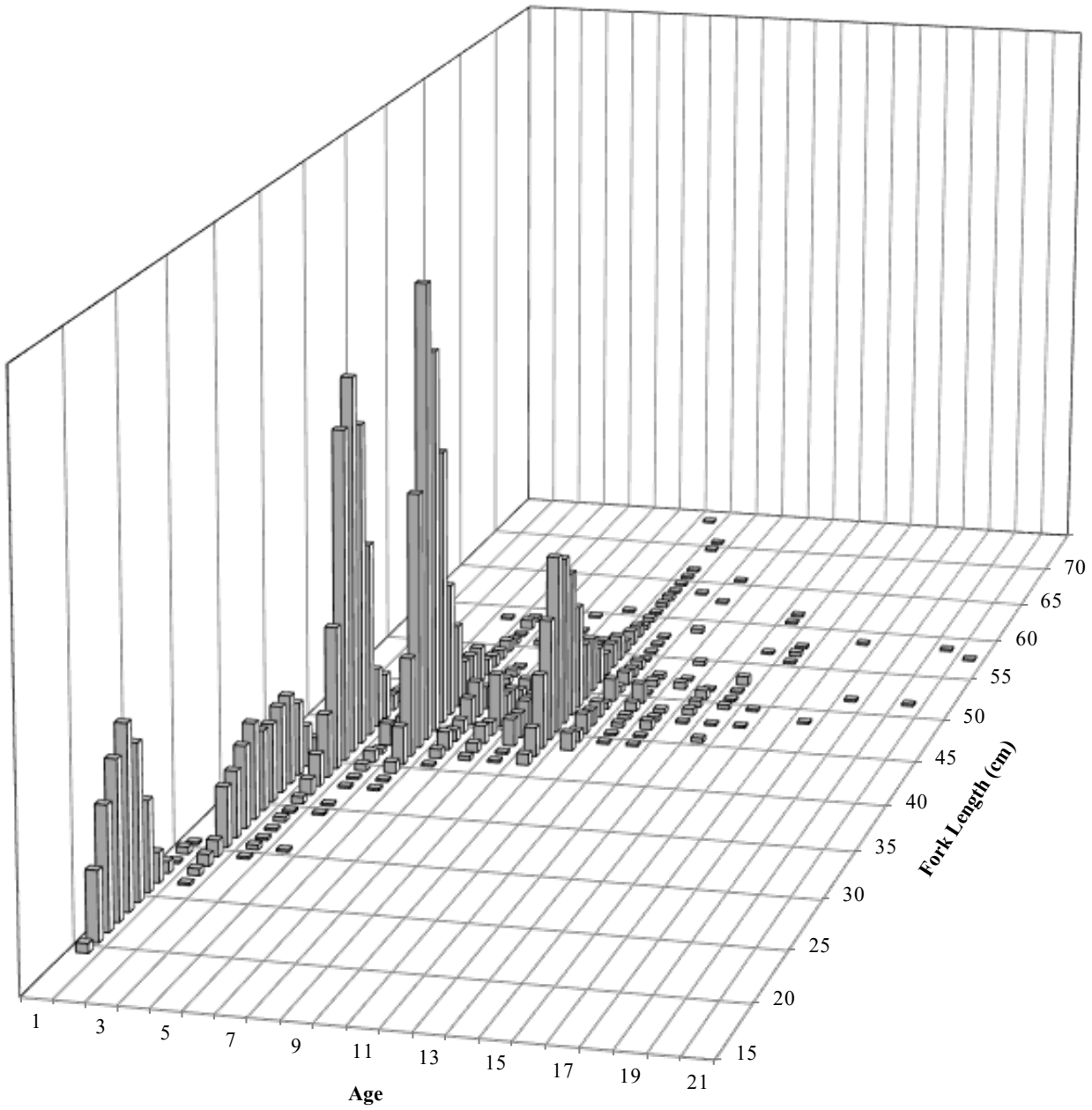


Figure 5. Age–length distribution of age-1+ Pacific hake from specimens collected during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey. Ages are based on interpretation of otoliths.

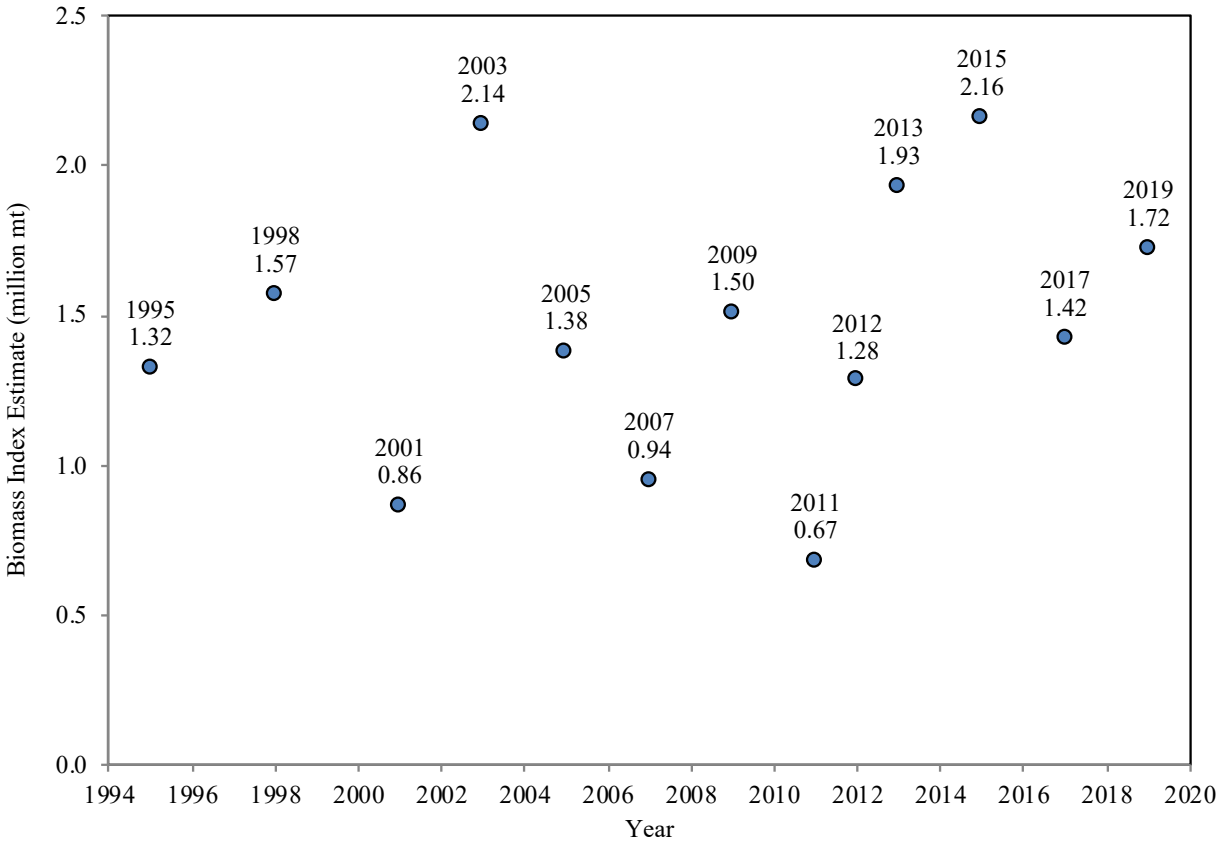


Figure 6. Coastwide biomass estimates (millions of metric tons) of adult Pacific hake (age-2+) from joint U.S.–Canada integrated acoustic and trawl surveys, 1995–2019. Each symbol displays survey year and biomass estimate. Historical biomass estimates (1995–2013) were reanalyzed in 2015 and may be different from those in previous reports.

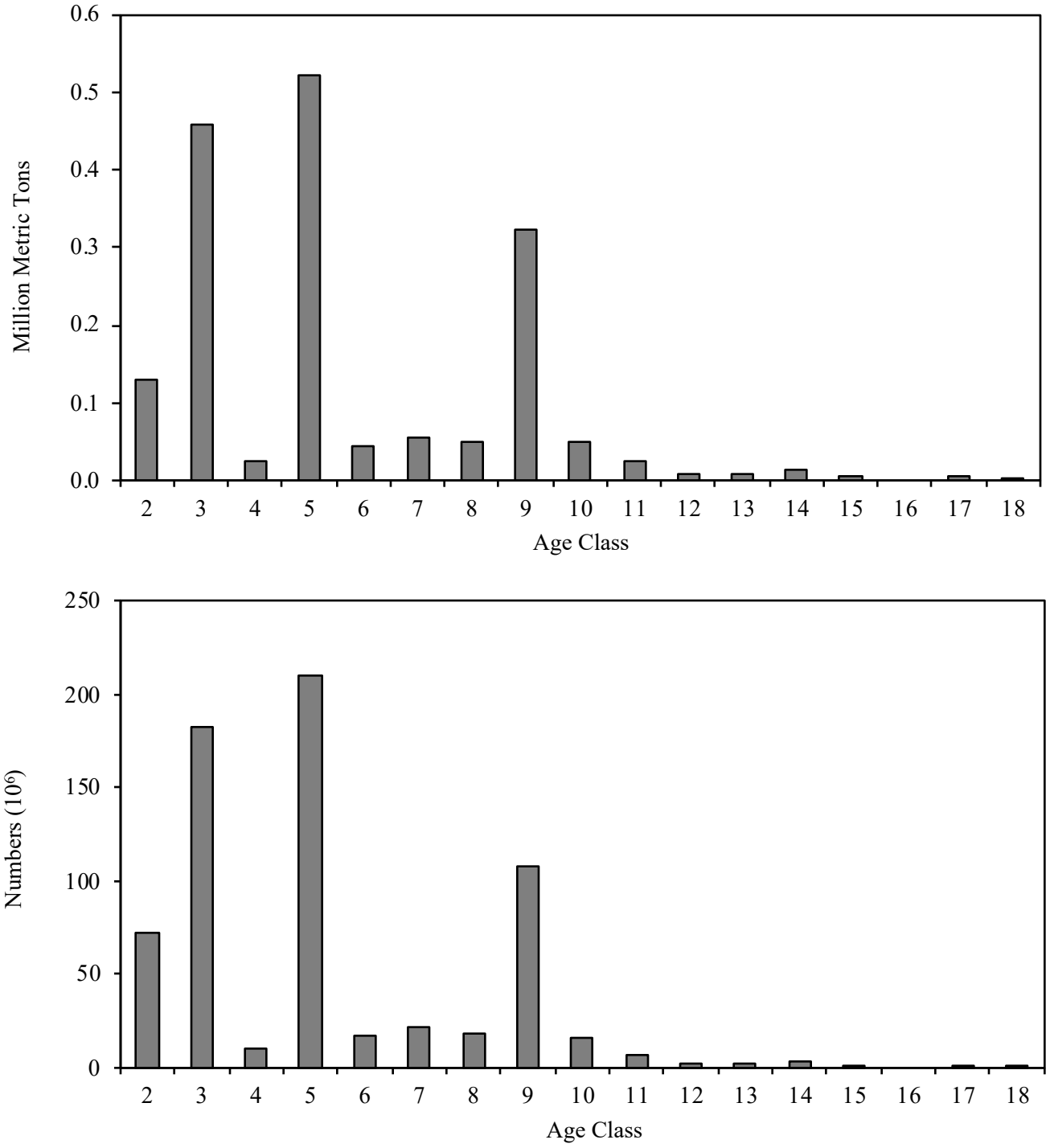


Figure 7. Acoustically weighted estimated biomass (million metric tons) and numbers (10^6) of adult (age-2+) Pacific hake by age class from the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

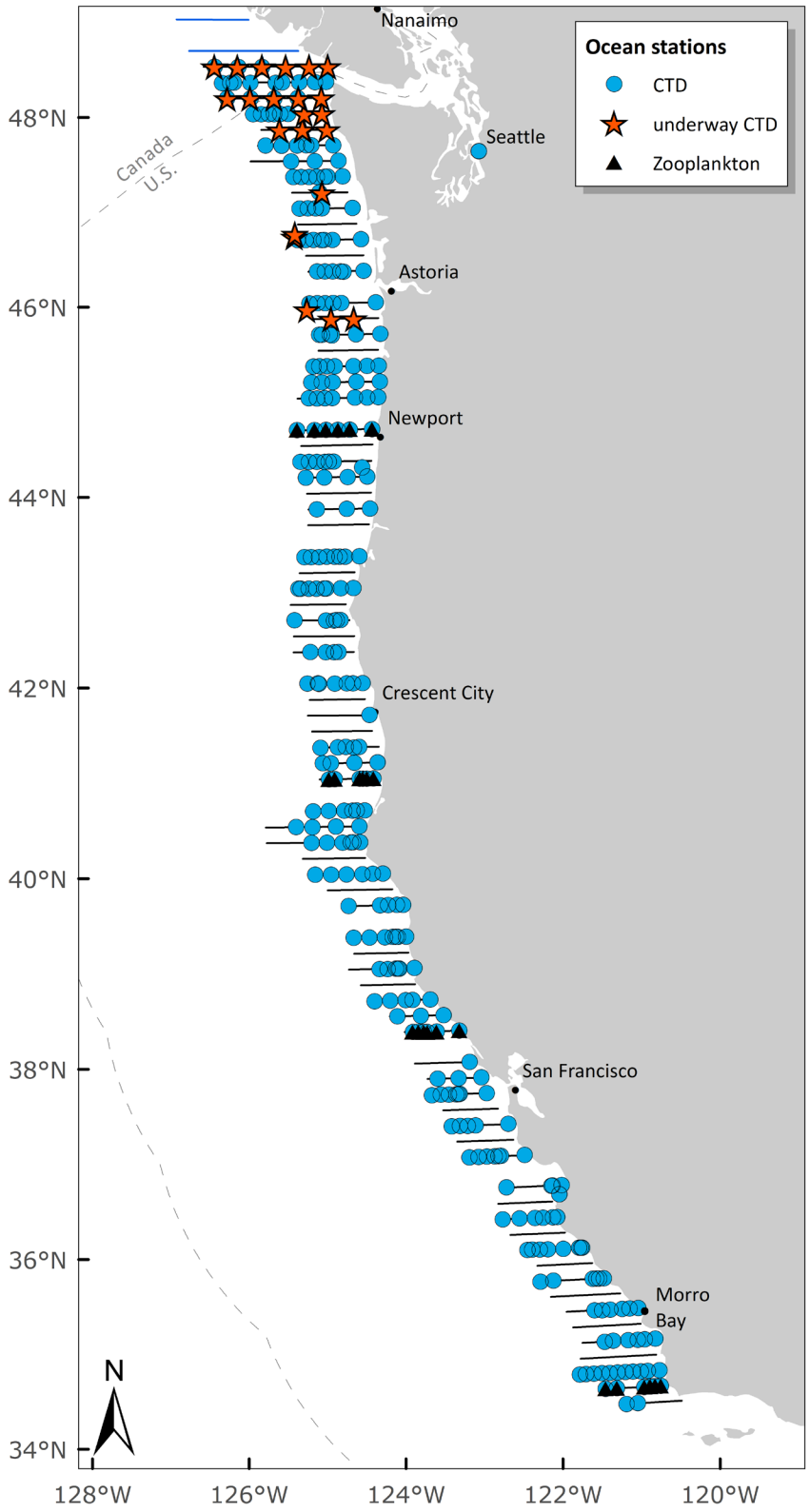


Figure 8. Acoustic transect lines with locations of zooplankton stations, conductivity-temperature-depth (CTD) rosette deployments, and underway CTDs (uCTDs) conducted by the *Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Table 1. Itinerary for the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

U.S. Leg 1

06/10–12	Personnel embark onto the NOAA Ship *Bell M. Shimada* in Newport (OR).
06/13	Personnel attempt to conduct an acoustic system calibration of the *Shimada* with standard targets while drifting and using dynamic positioning offshore of Newport. The *Shimada* starts transiting south.
06/16	Personnel conduct an acoustic system calibration of the *Shimada* offshore of Monterey (CA).
06/17	The survey starts with Transect 1 south of Point Conception (CA).
06/26	The *Shimada* conducts two Methot trawl operations.
06/27	The *Shimada* finishes Transect 20.
06/28–30	Inport San Francisco (CA); exchange personnel.

U.S. Leg 2

07/01	The *Shimada* leaves San Francisco and resumes the survey with Transect 21.
07/14	The *Shimada* finishes Transect 45; starts transit to Newport.
07/15–17	Inport Newport; exchange personnel.

U.S. Leg 3

07/18	The *Shimada* leaves Newport and transits south.
07/19	High winds and rough seas force the *Shimada* to seek shelter by Crescent City (CA).
07/20	The *Shimada* resumes the survey with Transect 46.
07/31	The *Shimada* finishes Transect 68.
08/01–04	Inport Newport; exchange personnel.

U.S. Leg 4

08/05	The *Shimada* leaves Newport.
08/06	The *Shimada* resumes the survey with Transect 69.
08/11	The cable to the port door breaks free shortly after the doors are up during Trawl 67; the door and net are recovered successfully.
08/12	The *Shimada* scouts for euphausiids and conducts two Methot trawl operations.
08/13	The *Shimada* conducts small-boat operations at Astoria (OR) to effect retermination of the cable to the port door. The *Shimada* transits north.
08/14	The *Shimada* resumes the survey with Transect 81.
08/17	The *Shimada* finishes Transect 86.
08/18–19	The *Shimada* conducts trawls equipped with a stereo camera; starts transit to Seattle (WA).
08/20	Personnel conduct an acoustic system calibration of the *Shimada* with standard targets in Elliott Bay, Seattle; inport Seattle; personnel disembark.

Table 1 (continued). Itinerary for the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Canada Leg 1

08/17	Personnel embark onto the *Nordic Pearl* in Nanaimo (BC). The *Nordic Pearl* transits to Coles Bay, Saanich Inlet, Vancouver Island (BC); personnel begin conducting an acoustic system calibration of the *Nordic Pearl* with standard targets.
08/18	Personnel complete the acoustic system calibration; the *Nordic Pearl* transits to the West Coast of Vancouver Island.
08/19	The *Nordic Pearl* recovers an acoustic mooring at Barkley Canyon, then starts surveying with Transect 87.
08/20–21	The *Nordic Pearl* finishes Transect 87, retrieves a second acoustic mooring, then seeks shelter by Ucluelet (BC) due to weather.
08/22	The *Nordic Pearl* resumes the survey with Transect 89.
08/24	The *Nordic Pearl* recovers a third acoustic mooring.
08/28	The *Nordic Pearl* finishes Transect 101; inport Port Hardy (BC); exchange personnel.

Canada Leg 2

08/29	The *Nordic Pearl* leaves Port Hardy and resumes the survey with Transect 103.
09/08	The *Nordic Pearl* fuels in Prince Rupert (BC).
09/12	Personnel conduct an acoustic system calibration of the *Nordic Pearl* with standard targets in Tasu Sound (BC).
09/13	The *Nordic Pearl* finishes the survey with Transect 145; starts transit to Nanaimo.
09/14	The *Nordic Pearl* fuels in Port Hardy.
09/15	Inport Nanaimo; personnel disembark.

Table 2. Simrad ER60 38-kHz acoustic system descriptions and settings used aboard the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey, and results from acoustic system calibrations with standard targets. Key: S_a = $10\log_{10}$ (area scattering coefficient), S_v = volume backscattering, *TS* = target strength.

		Calibrations	
	Survey system settings	16 June Monterey (CA)	20 August Elliott Bay (WA)
Transducer:	ES38B	--	--
Serial number:	30715	--	--
Transducer depth (m):	9.15	--	--
Pulse length (ms):	1.024	--	--
Transmitted power (W):	2,000	--	--
Angle sensitivity:	22.93	--	--
Two-way beam angle (dB):	-21.01	--	--
S_a correction (dB):	-0.56	-0.56	-0.55
S_v gain (dB):	25.41	25.41	25.43
TS Gain (dB):	25.97	25.97	25.98
3-dB beamwidth (deg.)			
Along (Minor):	6.57	6.57	6.63
Athwart (Major):	6.63	6.63	6.63
Angle offset (deg.)			
Along (Minor):	-0.06	-0.06	-0.06
Athwart (Major):	-0.05	-0.05	-0.01
Post-processing S_v threshold (dB):	-69	--	--
Sphere range from transducer (m):	--	20.00	25.00
Absorption coefficient (dB/m):	0.009855	0.008865	0.007992
Sound velocity (m/s):	1,480.6	1,499.0	1,495.7
Water temperature at transducer (°C):	--	14.0	13.5
Water temperature at sphere (°C):	--	11.4	13.0

Table 3. Coordinates (decimal degrees) and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

	Start		End		Length
Transect	Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)	(nmi)
1	34.3973	121.1431	34.3969	120.4338	35.1
2	34.5638	120.6822	34.5648	121.4041	35.7
3	34.7307	121.7241	34.7306	120.6942	50.8
4	34.8974	121.7080	34.8973	120.7264	48.3
5	35.0650	120.7262	35.0638	121.6742	46.6
6	35.2309	121.7859	35.2306	120.9053	43.2
7	35.3970	120.9260	35.3975	121.8609	45.7
8	35.5639	122.0559	35.5642	121.1509	44.2
9	35.7305	121.3547	35.7304	122.1807	40.2
10	35.8972	122.2167	35.8973	121.4952	35.1
11	36.0642	122.3393	36.0640	121.6168	35.0
12	36.2307	121.8349	36.2309	122.5562	34.9
13	36.3972	122.6487	36.3971	121.9237	35.0
14	36.5640	121.9823	36.5639	122.7013	34.6
15	36.7305	122.5794	36.7309	121.8504	35.1
16			dropped		
17	37.0634	122.3240	37.0640	123.0547	35.0
18	37.2305	122.4657	37.2308	123.2182	35.9
19	37.3974	123.2840	37.3975	122.5232	36.3
20	37.5635	122.6566	37.5643	123.3922	35.0
21	37.7307	122.8003	37.7311	123.5375	35.0
22	37.8960	122.8490	37.8972	123.5928	35.2
23	38.0640	123.7580	38.0635	123.0172	35.0
24			dropped		
25	38.3965	123.8856	38.3966	123.1415	35.0
26	38.5641	124.0837	38.5638	123.3503	34.4
27	38.7304	123.5310	38.7303	124.3049	36.2
28	38.8972	123.7285	38.8973	124.4725	34.7
29	39.0635	124.6305	39.0642	123.7330	41.8
30	39.2306	123.8074	39.2305	124.5550	34.7
31	39.3975	124.6390	39.3976	123.8374	37.2
32			dropped		
33	39.7313	123.8638	39.7296	124.6453	36.1
34	39.8972	124.9082	39.8974	124.0116	41.3
35	40.0645	125.1215	40.0642	124.1385	45.1
36	40.2316	124.3792	40.2306	125.2498	39.9
37	40.3969	124.4470	40.3982	125.7549	59.8
38	40.5630	125.7682	40.5647	124.4540	59.9

Table 3 (continued). Coordinates (decimal degrees) and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

	Start		End		Length
Transect	Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)	(nmi)
39	40.7298	125.2023	40.7309	124.3723	37.7
40			dropped		
41	41.0638	125.0055	41.0638	124.2336	34.9
42	41.2308	124.1817	41.2283	124.9838	36.2
43	41.3980	125.0737	41.3968	124.1578	41.2
44	41.5633	124.2496	41.5650	125.1041	38.4
45	41.7341	125.1602	41.7298	124.2825	39.3
46	41.8992	124.3439	41.8976	125.1337	35.3
47	42.0640	124.3715	42.0640	125.1597	35.1
48			dropped		
49	42.3982	125.3597	42.3969	124.4904	38.5
50	42.5632	124.4786	42.5648	125.3532	38.6
51	42.7325	125.3389	42.7293	124.5464	34.9
52	42.8977	124.5937	42.8972	125.3963	35.3
53	43.0631	125.2799	43.0632	124.4830	34.9
54	43.2298	125.2615	43.2310	124.4606	35.0
55	43.3968	124.3844	43.3958	125.1852	34.9
56			dropped		
57	43.7305	124.2359	43.7307	125.1326	38.9
58	43.8967	125.1251	43.8975	124.2120	39.5
59	44.0638	124.1955	44.0635	125.1445	40.9
60	44.2332	125.2115	44.2306	124.1876	44.0
61	44.3976	124.1808	44.3968	125.2317	45.1
62	44.5647	125.2245	44.5687	124.1580	45.6
63	44.7306	124.1303	44.7299	125.2790	49.0
64			dropped		
65	45.0633	124.0580	45.0640	125.2726	51.5
66	45.2315	125.0643	45.2301	124.0276	43.8
67	45.3973	125.0289	45.3972	124.0367	41.8
68	45.5645	124.0450	45.5640	124.9499	38.0
69	45.7308	124.0055	45.7312	124.9338	38.9
70	45.8983	124.0333	45.8971	125.0394	42.0
71	46.0664	125.1677	46.0637	124.0627	46.0
72			dropped		
73	46.3976	125.0893	46.3974	124.2441	35.0
74	46.5626	124.2384	46.5644	125.1244	36.6
75	46.7309	124.2723	46.7309	125.3062	42.5
76	46.8969	125.2491	46.8973	124.3401	37.3

Table 3 (continued). Coordinates (decimal degrees) and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

	Start		End		Length
Transect	Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)	(nmi)
77	47.0636	125.2490	47.0637	124.3920	35.0
78	47.2299	124.4707	47.2309	125.3312	35.1
79	47.3970	124.5375	47.3980	125.3990	35.0
80	47.5645	125.9766	47.5639	124.6014	55.7
81	47.7308	125.8616	47.7298	124.6810	47.6
82	47.8958	124.7722	47.8975	125.8122	41.8
83	48.0636	126.0320	48.0628	124.8535	47.3
84	48.2310	124.8543	48.2280	126.3500	59.8
85	48.3989	126.5357	48.3953	124.7725	70.2
86	48.5630	124.6655	48.5646	126.7259	81.8

Table 4. Coordinates (decimal degrees) and length of transects conducted by the Canadian chartered F/V *Nordic Pearl* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

	Start		End		Length
Transect	Latitude (°N)	Longitude (°W)	Latitude (°N)	Longitude (°W)	(nmi)
87	48.7310	125.2155	48.7309	126.9599	69.0
88		dropped			
89	49.0639	126.0103	49.0632	127.1681	45.5
90	49.2308	127.4391	49.2302	126.3518	42.6
91	49.3965	126.7304	49.3983	127.6288	35.1
92	49.5652	127.8107	49.5641	126.8919	35.8
93	49.7305	127.0146	49.7316	127.9212	35.2
94	49.8971	128.1738	49.8997	127.5332	24.8
95	50.0637	127.8540	50.0635	128.5691	27.5
96		dropped			
97	50.3980	128.6895	50.3955	128.0349	25.0
98	50.5646	128.2959	50.5645	128.8864	22.5
99	50.7297	129.4090	50.7309	128.4521	36.3
100	50.8973	128.4697	50.8959	129.7129	47.0
101	51.0641	129.9173	51.0665	127.6396	85.9
103	51.3976	128.0514	51.3961	130.4467	89.7
105	51.7300	130.9179	51.7306	128.1949	101.2
107	52.0635	128.5506	52.0641	130.8425	84.5
109	52.3973	131.0297	52.3971	129.2872	63.8
111	52.7304	129.5366	52.7308	130.9782	52.4
113	53.0628	130.9310	53.0639	129.8204	40.0
115	53.3986	130.5898	53.3973	131.0758	17.4
117	53.7303	130.8832	53.7307	130.4883	14.0
119	54.0643	130.9267	54.0648	131.0858	5.6
121	54.7988	131.1497	54.3008	131.1500	29.9
123	54.2068	131.7117	54.6848	131.7259	28.7
125	54.1313	132.2992	54.7009	132.2992	34.2
127	54.6934	132.8732	54.1727	132.8731	31.2
129	54.5642	133.1544	54.5636	134.1524	34.7
131	54.2317	134.1061	54.2306	133.1500	33.5
133	53.8981	133.2983	53.8974	133.9319	22.4
135	53.5649	133.3997	53.5639	133.0255	13.3
137	53.2307	132.6735	53.2307	133.2971	22.4
139		dropped			
140	52.7304	132.1280	52.7307	132.5813	16.5
141		dropped			
143	52.2322	131.7791	52.2308	131.4581	11.8
144	52.0636	131.6039	52.0639	131.1612	16.3
145	51.8976	131.2032	51.8946	130.9650	8.8

Table 5. Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)		Catch		
											Pacific Hake		Other
no.	Transect	Date	(PDT)	(min.)[a]	Latitude (°N)	Longitude (°W)	Gear[b]	Bottom	Gear[c]	Surface	(kg)	Number	(kg)
1	1	17 Jun	9:52	15.5	34.4038	120.6570	336	391	7.94	13.02	56.3	769	2.3
2	3	18 Jun	14:59		trawl aborted because of marine mammals								
3	4	19 Jun	13:12	15.3	34.8987	120.9077	227	249	9.16	14.42	46.3	866	14.0
4	4	19 Jun	15:09	5.1	34.8945	120.8765	172	200	9.76	14.43	--	--	102.5
5	5	20 Jun	8:02	15.5	35.0627	121.4547	141	432	9.43	14.55	--	--	3.1
6	7	20 Jun	18:29		trawl aborted because of marine mammals								
7	7	20 Jun	19:31	20.2	35.3936	121.1582	198	330	7.83	15.72	51.9	848	0.2
8	8	21 Jun	14:26	15.5	35.5583	121.4342	341	609	7.84	15.25	103.1	1,415	0.7
9	8	21 Jun	18:18	11.0	35.5620	121.2995	272	284	8.64	14.35	11.9	173	106.9
10	9	22 Jun	10:34	22.4	35.7302	121.7385	321	946	7.52	15.65	91.4	875	0.5
11	10	22 Jun	18:58	20.1	35.9025	121.5822	388	578	7.57	13.70	52.5	287	7.8
12	11	23 Jun	10:17	25.8	36.0648	121.7403	260	822	8.54	13.73	84.3	1,009	3.0
13	13	24 Jun	8:21	22.8	36.3962	122.0503	294	637	7.92	14.01	60.9	303	7.4
14	14	24 Jun	13:08	16.3	36.5446	121.9968	197	630	7.41	14.96	0.3	265	2.2
15	17	25 Jun	14:11	15.1	37.0603	122.6848	345	378	6.16	15.26	304.3	1,229	2.5
16	17	25 Jun	16:43	8.1	37.0618	122.6612	241	261	6.84	15.31	0.8	1	25.8
17	18	26 Jun	10:08	20.2	37.2358	122.8717	306	317	7.73	14.28	108.5	306	2.3
18	19	27 Jun	8:40		trawl aborted because of gear issues								
19	20	27 Jun	16:57	17.4	37.5640	123.0483	270	541	8.23	13.76	177.2	859	0.4
20	22	2 Jul	11:51	20.2	37.9025	123.4431	285	328	7.60	11.20	213.3	514	6.7
21	23	2 Jul	18:29		trawl aborted because of weather								
22	23	3 Jul	8:39	8.3	38.0564	123.5303	276	428	7.62	10.30	518.1	998	7.3
23	26	4 Jul	8:53	24.9	38.5621	123.8029	96	1,575	9.24	12.76	--	--	0.8
24	26	4 Jul	12:16	30.5	38.5600	123.7883	290	1,450	7.44	13.02	113.5	322	7.6

Table 5 (continued). Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)		Catch		
											Pacific Hake		Other
no.	Transect	Date	(PDT)	(min.)[a]	Latitude (°N)	Longitude (°W)	Gear[b]	Bottom	Gear[c]	Surface	(kg)	Number	(kg)
25	27	5 Jul	8:14	7.2	38.7320	123.8279	237	281	7.79	10.31	140.5	334	--
26	29	6 Jul	8:25	4.8	39.0691	123.9506	211	246	7.90	12.19	626.9	1,310	18.2
27	30	6 Jul	14:11	3.3	39.2398	123.9604	162[d]	239	8.12	10.93	395.3	897	13.7
28	31	7 Jul	9:48	43.4	39.3938	124.3887	215[d]	1,707	8.07	10.97	184.3	392	106.8
29	31	7 Jul	15:01	9.4	39.4012	123.9842	236	379	7.75	10.79	167.9	413	14.1
30	33	8 Jul	8:08	42.1	39.7312	124.2136	258[d]	1,293	7.21	10.37	204.8	441	5.1
31	35	9 Jul	9:40	40.3	40.0631	124.5125	258	865	7.44	11.39	168.6	330	50.0
32	35	9 Jul	14:27	23.5	40.0632	124.2667	171	321	8.05	9.97	57.3	89	8.4
33	37	10 Jul	8:49	26.6	40.3948	124.7948	311	1,919	6.65	12.95	412.5	857	0.1
34	38	11 Jul	8:05		trawl aborted because of gear issues								
35	38	11 Jul	9:41	20.4	40.5644	124.7252	359	983	6.93	13.17	607.4	1,258	4.6
36	39	11 Jul	15:50	16.5	40.7295	124.8352	338	2,242	6.78	13.67	647.7	1,363	--
37	39	11 Jul	19:51	8.3	40.7190	124.5107	217	228	7.79	12.25	650.8	1,339	165.1
38	41	12 Jul	13:54	6.2	41.0465	124.4185	304	390	7.23	15.12	391.6	790	1.9
39	42	13 Jul	8:23	45.4	41.2198	124.8947	399	1,407	5.75	14.72	63.0	113	4.7
40	44	13 Jul	18:34	16.9	41.5648	124.5193	354	383	6.98	13.80	700.9	1,389	94.8
41	44	14 Jul	8:26	30.4	41.5590	124.9828	408[d]	1,059	5.60	12.56	22.8	42	4.7
42	46	20 Jul	14:14	22.7	41.8850	124.5519	320	326	6.60	9.40	412.2	817	9.5
43	49	21 Jul	15:34	30.0	42.3883	124.7315	244	261	7.25	10.52	10.9	26	1.7
44	51	22 Jul	10:59	45.0	42.7300	125.1585	327	990	6.91	16.31	5.4	9	7.5
45	51	22 Jul	16:22	4.9	42.7263	124.7283	247	270	7.38	15.65	1,561.6	3,032	6.7
46	52	23 Jul	8:39	8.4	42.8943	124.9794	271	1,015	7.19	16.16	573.9	1,114	1.6
47	53	23 Jul	14:45	36.9	43.0708	125.0856	349	>1,000	6.43	16.51	111.7	235	3.4
48	54	24 Jul	9:41	14.5	43.2257	124.7650	334	344	6.64	16.55	311.1	633	1.8

Table 5 (continued). Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)		Catch		
											Pacific Hake		Other
no.	Transect	Date	(PDT)	(min.)[a]	Latitude (°N)	Longitude (°W)	Gear[b]	Bottom	Gear[c]	Surface	(kg)	Number	(kg)
49	55	24 Jul	16:22	17.9	43.3933	124.7406	468	516	5.96	17.10	214.2	418	9.8
50	57	25 Jul	10:58	39.4	43.7210	125.0668	333	1,364	6.34	17.03	111.3	215	--
51	58	25 Jul	15:46	14.7	43.8957	124.8715	276	288	6.73	15.24	93.1	182	1.6
52	58	25 Jul	18:34	21.3	43.8971	124.9229	456	462	5.87	14.58	77.4	187	16.2
53	59	26 Jul	11:46	28.2	44.0597	124.6249	120	128	7.46	15.51	171.2	371	55.7
54	59	26 Jul	16:11	14.1	44.0552	124.9563	258	438	6.88	16.38	690.9	1,424	10.4
55	61	27 Jul	15:13	26.5	44.3777	124.8326	393	419	6.27	16.25	414.5	845	4.8
56	65	29 Jul	10:07	35.3	45.0540	124.7596	352	500	6.24	18.62	44.3	83	1.2
57	66	30 Jul	13:42	28.9	45.2223	124.6619	387	404	6.05	18.78	142.6	276	5.0
58	66	30 Jul	18:04	30.7	45.2160	124.3049	186	197	7.25	18.75	0.6	1	22.2
59	68	31 Jul	14:37	19.1	45.5569	124.5612	364	422	4.99	17.95	104.5	184	2.8
60	69	6 Aug	12:32	5.7	45.7268	124.3027	131	144	7.22	16.69	114.0	238	44.5
61	69	6 Aug	16:35	18.9	45.7295	124.7517	313	349	6.36	18.17	86.9	184	2.1
62	71	7 Aug	14:40	18.3	46.0505	124.7303	295	311	6.75	18.35	25.7	46	66.3
63	73	8 Aug	10:40	21.3	46.3896	124.6048	470	504	5.70	17.68	313.6	617	66.8
64	75	9 Aug	11:06	20.2	46.7318	124.8692	356	505	6.25	16.79	23.0	42	1.7
65	75	9 Aug	13:55	15.1	46.7320	124.8735	429	495	5.94	17.10	154.1	302	13.7
66	78	10 Aug	15:13	13.5	47.2405	124.8998	510	515	5.48	16.48	100.5	186	69.2
67	79	11 Aug	9:11	8.1	47.4269	124.8278	238	556	7.15	14.80	187.6	332	19.9
68	81	14 Aug	trawl aborted because of marine mammals										
69	81	14 Aug	14:16	5.4	47.7293	124.8739	98	105	7.64	16.32	527.1	981	19.2
70	82	14 Aug	19:47	20.3	47.8970	125.2625	344	388	6.65	18.71	118.2	232	20.6
71	83	15 Aug	12:29	8.6	48.0650	125.6263	326	410	6.26	18.13	157.2	282	26.4
72	84	16 Aug	10:39	27.4	48.2308	125.5758	138	159	7.55	13.42	--	--	654.0

Table 5 (continued). Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)		Catch		
											Pacific Hake		Other
no.	Transect	Date	(PDT)	(min.)[a]	Latitude (°N)	Longitude (°W)	Gear[b]	Bottom	Gear[c]	Surface	(kg)	Number	(kg)
73	85	17 Aug	9:05	14.5	48.3972	125.3868	130[d]	173	7.08	13.69	518.3	575	417.0
74	86	18 Aug	10:08		trawl aborted because of marine mammals								
75	85	18 Aug	15:51	11.8	48.3936	125.4670	122	131	7.52	14.67	open codend		
76	84	19 Aug	8:36	5.1	48.2242	125.5345	138[d]	152	7.56	16.69	open codend		
77	84	19 Aug	10:16	12.8	48.2267	125.5836	149	152	7.69	17.01	open codend		
78	84	19 Aug	12:18	1.1	48.2341	125.5485	145	151	7.56	16.89	open codend		

[a] Duration is the time during trawling between "Target Depth" and "Haul Back."

[b] Gear depths were measured at the foot rope.

[c] Gear temperatures were measured at the head rope.

[d] Vertical net opening for these trawls was not recorded. Gear depths were calculated using an average net opening of all other trawls.

Table 6. Station and catch data summary of midwater trawls conducted by the Canadian chartered F/V *Nordic Pearl* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)	Catch (kg)	
no.	Transect	Date	(PDT)	(min.)*	Latitude (°N)	Longitude (°W)	Gear	Bottom	Gear	Pacific Hake	Other
1	87	19 Aug	14:22	14.5	48.7306	125.5971	173	190	8.38	4,338.5	>123.1
2	87	19 Aug	18:29	24.6	48.7282	126.3291	414	515	5.71	16.8	>14.1
3	89	22 Aug	10:06	5.5	49.0629	126.3940	102	130	7.74	9,043.1	26.9
4	91	23 Aug	9:31	8.0	49.4186	127.2483	176	302	7.04	191.4	>21.3
5	91	23 Aug	10:29	8.0	49.4097	127.2532	279	302	6.47	147.8	>102.6
6	97	25 Aug	13:18	8.4	50.4002	128.4765	304	345	6.07	460.0	>23.5
7	97	25 Aug	15:24	27.2	50.4135	128.2816	143	174	7.20	--	1,815.8
8	98	26 Aug	7:52	3.8	50.5861	128.4951	150	174	--	3,566.6	63.4
9	99	26 Aug	14:51	25.1	50.7276	129.0651	156	190	6.85	--	1,773.9
10	100	27 Aug	13:11	5.0	50.8963	129.6172	171	170	6.87	--	>279.9
11	101	28 Aug	10:07	15.5	51.0667	128.1081	135	170	6.87	2.4	134.6
12	101	28 Aug	12:38	13.1	51.0613	127.9023	117	156	6.94	--	>304.8
13	107	2 Sep	12:28	29.3	52.0649	130.3943	293	350	5.57	1.0	>2.4
14	111	3 Sep	16:20	22.2	52.7309	129.7940	177	213	6.26	1.1	140.7
15	113	4 Sep	13:45	14.3	53.0642	130.7872	82	123	8.14	--	194.0
16	113	4 Sep	17:17	16.1	53.0641	130.2052	149	215	6.51	21.8	>266.0
17	121	6 Sep	9:29	15.9	54.5251	131.1508	91	150	7.75	--	>265.2
18	125	7 Sep	8:33	20.9	54.2750	132.2986	150	210	6.35	1.9	>153.6
19	127	7 Sep	16:20	20.5	54.6288	132.8720	204	260	6.15	--	>21.7
20	129	9 Sep	10:01	16.3	54.5638	133.7334	204	250	6.02	--	>9.6
21	129	9 Sep	13:00	20.4	54.5640	134.0809	333	1,000	5.42	--	>18.7
22	145	13 Sep	12:22	23.1	51.9667	131.1850	396	800	5.94	12.4	50.9

* Duration is the time during trawling between "Target Depth" and "Haul Back."

Table 7. Station data summary of Methot trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl			Time	Duration	Start position		Depth (m)		Temp. (°C)	
no.	Transect	Date	(PDT)	(min.)[a]	Latitude (°N)	Longitude (°W)	Gear	Bottom	Gear	Surface
501	19	26 Jun	16:28	24.9	37.3947	123.2672	167	>1,500	8.38	14.51
502	19	26 Jun	18:36	18.0	37.3858	123.2467	90	1,305	9.22	14.40
503	68	31 Jul	20:05	15.2	45.5623	124.3275	29	164	9.16	18.21
504	62	1 Aug	6:44	20.0	44.5643	124.9632	355	824	6.18	18.16
505	77	12 Aug	14:39	20.0	47.0663	124.9706	154	583	7.23	17.26
506	78	12 Aug	18:22	6.2	47.2375	124.9134	167	608	7.27	17.75

[a] Duration is the time during trawling between "Target Depth" and "Haul Back."

Table 8. Catch by species from 66 midwater trawls conducted in U.S. waters by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	(%)	Numbers
Pacific hake	*Merluccius productus*	14,294.4	87.9	35,890
yellowtail rockfish	*Sebastes flavidus*	363.7	2.2	249
North Pacific spiny dogfish	*Squalus suckleyi*	316.3	1.9	807
widow rockfish	*Sebastes entomelas*	158.2	1.0	143
shortbelly rockfish	*Sebastes jordani*	118.5	0.7	1,435
northern anchovy	*Engraulis mordax*	103.3	0.6	8,826
jack mackerel	*Trachurus symmetricus*	100.6	0.6	421
splitnose rockfish	*Sebastes diploproa*	93.4	0.6	260
king-of-the-salmon	*Trachipterus altivelis*	82.1	0.5	33
Pacific ocean perch	*Sebastes alutus*	63.7	0.4	82
cat shark unidentified	Scyliorhinidae	59.4	0.4	109
rougheye/blackspotted rockfish	*Sebastes sp.*	59.2	0.4	41
chilipepper rockfish	*Sebastes goodei*	53.6	0.3	72
Pacific herring	*Clupea pallasi*	51.5	0.3	535
opalescent inshore squid	*Doryteuthis opalescens*	51.2	0.3	1,938
jellyfish unidentified	Scyphozoa	28.5	0.2	--
California headlightfish	*Diaphus theta*	27.2	0.2	5,923
brown cat shark	*Apristurus brunneus*	22.6	0.1	43
bocaccio	*Sebastes paucispinis*	21.4	0.1	11
king salmon	*Oncorhynchus tshawytscha*	21.3	0.1	7
northern lampfish	*Stenobrachius leucopsarus*	15.4	<0.1	3,162
redstripe rockfish	*Sebastes proriger*	14.2	<0.1	22
eulachon	*Thaleichthys pacificus*	12.8	<0.1	333
longnose skate	*Raja rhina*	12.1	<0.1	2
egg-yolk jellyfish	*Phacellophora camtschatica*	11.2	<0.1	8
boreal clubhook squid	*Onychoteuthis borealijaponicus*	10.2	<0.1	37
sea pickle unidentified	*Pyrosoma* sp.	7.2	<0.1	542
sunrise jellyfish	*Chrysaora melanaster*	7.0	<0.1	10
lanternfish unidentified	Myctophidae	6.4	<0.1	1,350
shrimp unidentified	Decapoda	5.3	<0.1	1,074
American shad	*Alosa sapidissima*	5.1	<0.1	8
salp unidentified	Thaliacea	4.9	<0.1	--
enoploteuthid cephalopod	*Abraliopsis felis*	4.5	<0.1	1,012
darkblotched rockfish	*Sebastes crameri*	4.4	<0.1	7
shortraker rockfish	*Sebastes borealis*	4.3	<0.1	1
coho salmon	*Oncorhynchus kisutch*	3.7	<0.1	2
moon jellyfish	*Aurelia labiata*	3.5	<0.1	6
Pacific electric ray	*Torpedo californica*	3.1	<0.1	1
medusafish	*Icichthys lockingtoni*	3.1	<0.1	6
robust clubhook squid	*Onykia robusta*	3.1	<0.1	1

Table 8 (continued). Catch by species from 66 midwater trawls conducted in U.S. waters by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	(%)	Numbers
canary rockfish	*Sebastes pinniger*	2.2	<0.1	1
invertebrate unidentified	--	2.0	<0.1	--
pink salmon	*Oncorhynchus gorbuscha*	1.9	<0.1	1
North Pacific armhook squid	*Gonatopsis borealis*	1.4	<0.1	2
yellowmouth rockfish	*Sebastes reedi*	1.4	<0.1	1
garnet lampfish	*Stenobrachius nannochir*	1.3	<0.1	235
jewel squid	*Histioteuthis heteropsis*	1.1	<0.1	24
Pacific lamprey	*Lampetra tridentata*	1.0	<0.1	4
bathypelagic shrimp unidentified	*Pasiphaea* sp.	1.0	<0.1	668
lanternfish unidentified	*Tarletonbeania* sp.	1.0	<0.1	348
eelpout unidentified	Zoarcidae	1.0	<0.1	52
moon jellyfish	*Aurelia aurita*	1.0	<0.1	1
sablefish	*Anoplopoma fimbria*	0.9	<0.1	1
squid unidentified	Teuthida	0.8	<0.1	242
fish unidentified	Osteichthyes	0.7	<0.1	16
blue lanternfish	*Tarletonbeania crenularis*	0.7	<0.1	233
surf smelt	*Hypomesus pretiosus*	0.7	<0.1	143
rabbit-eared salp	*Thetys vagina*	0.6	<0.1	5
California lanternfish	*Symbolophorus californiensis*	0.6	<0.1	64
sergestid shrimp unidentified	Sergestidae	0.5	<0.1	733
moon jellyfish	*Aurelia* sp.	0.4	<0.1	1
yellow-ringed octopus	*Japetella diaphana*	0.3	<0.1	1
viperfish unidentified	Chauliodontidae	0.3	<0.1	9
shortspine thornyhead	*Sebastolobus alascanus*	0.3	<0.1	1
glass shrimp	*Pasiphaea pacifica*	0.2	<0.1	55
slender barracudina	*Lestidiops ringens*	0.1	<0.1	70
smelt unidentified	Osmeridae	0.1	<0.1	25
deepwater eelpout	*Lycodapus endemoscotus*	0.1	<0.1	7
Pacific viperfish	*Chauliodus macouni*	0.1	<0.1	9
--	*Aequorea* sp.	0.1	<0.1	2
eelpout unidentified	*Lycodapus* sp.	0.1	<0.1	4
octopus squid	*Octopoteuthis deletron*	0.1	<0.1	1
clawed armhook squid	*Gonatus onyx*	<0.1	<0.1	43
pelagic octopus unidentified	Bolitaenidae	<0.1	<0.1	1
ribbon barracudina	*Arctozenus risso*	<0.1	<0.1	2
cone squid	*Taonius pavo*	<0.1	<0.1	18
longfin dragonfish	*Tactostoma macropus*	<0.1	<0.1	2
squat lobster/pinch bug unidentified	Galatheoidea	<0.1	<0.1	3
Pacific sergestid shrimp	*Sergestes similis*	<0.1	<0.1	61
scabbardfish	*Lepidopus xantusi*	<0.1	<0.1	1

Table 8 (continued). Catch by species from 66 midwater trawls conducted in U.S. waters by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	(%)	Numbers
euphausiid unidentified	Euphausiidae	<0.1	<0.1	810
octopus unidentified	Octopodidae	<0.1	<0.1	7
sandpaper squid	*Cranchia scabra*	<0.1	<0.1	2
tropical hatchetfish	*Argyropelecus lychnus*	<0.1	<0.1	12
rex sole larvae	*Glyptocephalus zachirus*	<0.1	<0.1	16
California smoothtongue	*Leuroglossus stilbius*	<0.1	<0.1	6
scaleless dragonfish unidentified	Melanostomiidae	<0.1	<0.1	2
pandalid shrimp unidentified	Pandalidae	<0.1	<0.1	1
barracudina unidentified	Paralepididae	<0.1	<0.1	6
broadfin lanternfish	*Nannobrachium ritteri*	<0.1	<0.1	1
shining tubeshoulder	*Sagamichthys abei*	<0.1	<0.1	1

Table 9. Catch by species from one midwater trawl conducted in Canadian waters by the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	(%)	Numbers
Pacific hake	*Merluccius productus*	518.3	55.4	575
walleye pollock	*Gadus chalcogrammus*	412.8	44.1	955
eulachon	*Thaleichthys pacificus*	1.8	0.2	42
pink salmon	*Oncorhynchus gorbuscha*	1.7	0.2	1
king salmon	*Oncorhynchus tshawytscha*	0.5	<0.1	1
Pacific herring	*Clupea pallasi*	0.2	<0.1	3

Table 10. Catch by species from 22 midwater trawls conducted in Canadian waters by the Canadian chartered F/V *Nordic Pearl* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	Numbers
Pacific hake	*Merluccius productus*	17,804.77	18,784
redstripe rockfish	*Sebastes proriger*	1,498.12	5,819
widow rockfish	*Sebastes entomelas*	1,184.61	679
yellowtail rockfish	*Sebastes flavidus*	958.72	682
walleye pollock	*Gadus chalcogrammus*	757.23	850
Pacific herring	*Clupea pallasi*	748.29	7,996
silvergray rockfish	*Sebastes brevispinis*	96.72	43
lion's mane jellyfish	*Cyanea capillata*	87.51	--
splitnose rockfish	*Sebastes diploproa*	62.82	114
eulachon	*Thaleichthys pacificus*	59.71	>415
rougheye/blackspotted rockfish	*Sebastes* sp.	42.97	32
king salmon	*Oncorhynchus tshawytscha*	31.73	13
lingcod	*Ophiodon elongatus*	29.08	6
Pacific ocean perch	*Sebastes alutus*	25.62	25
sharpchin rockfish	*Sebastes zacentrus*	25.42	109
canary rockfish	*Sebastes pinniger*	22.23	12
California headlightfish	*Diaphus theta*	>16.17	--
North Pacific spiny dogfish	*Squalus suckleyi*	15.98	41
deep sea red shrimps unidentified	Euphausiacea	>14.4	--
egg-yolk jellyfish	*Phacellophora camtschatica*	12.98	--
bocaccio	*Sebastes paucispinis*	12.86	13
jellyfish unidentified	Scyphozoa	>12.34	--
rex sole	*Glyptocephalus zachirus*	>12.29	>50
pygmy rockfish	*Sebastes wilsoni*	10.38	156
spotted ratfish	*Hydrolagus colliei*	7.94	12
arrowtooth flounder	*Atheresthes stomias*	7.41	7
sea whip	*Balticina septentrionalis*	6.58	--
moon jellyfish	*Aurelia aurita*	>6.58	--
glass shrimp	*Pasiphaea pacifica*	>5.4	--
northern lampfish	*Stenobrachius leucopsarus*	5.29	--
dover sole	*Microstomus pacificus*	4.54	15
chum salmon	*Oncorhynchus keta*	3.60	1
sunrise jellyfish	*Chrysaora melanaster*	3.18	--
harlequin rockfish	*Sebastes variegatus*	2.60	14
lanternfish unidentified	Myctophidae	>2.01	--
Chrysaora jellyfish unidentified	*Chrysaora* sp.	1.79	--
opalescent inshore squid	*Doryteuthis opalescens*	>1.7	--
yellowmouth rockfish	*Sebastes reedi*	1.54	1
Pacific lamprey	*Lampetra tridentata*	>1.07	22
squid unidentified	Teuthida	>1.03	--

Table 10 (continued). Catch by species from 22 midwater trawls conducted in Canadian waters by the Canadian chartered F/V *Nordic Pearl* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Common name	Scientific name	Weight (kg)	Numbers
northern flashlightfish	*Protomyctophum thompsoni*	0.86	--
salmon unidentified	*Oncorhynchus* sp.	0.82	8
magistrate armhook squid	*Berryteuthis magister*	0.65	--
brown cat shark	*Apristurus brunneus*	0.57	1
moon jellyfish unidentified	*Aurelia* sp.	0.54	--
ragfish	*Icosteus aenigmaticus*	0.46	1
blue lanternfish	*Tarletonbeania crenularis*	>0.44	--
purple cone jellyfish	*Periphylla periphylla*	0.29	--
spot prawn	*Pandalus platyceros*	0.22	--
Pacific viperfish	*Chauliodus macouni*	>0.19	8
Pacific hagfish	*Eptatretus stoutii*	0.18	1
shortbelly rockfish	*Sebastes jordani*	0.13	1
mud starfish	*Ctenodiscus crispatus*	0.13	--
medusafish	*Icichthys lockingtoni*	0.12	1
deepsea smelt unidentified	Bathylagidae	0.12	--
prowfish	*Zaprora silenus*	0.08	--
northern pearleye	*Benthalbella dentata*	0.05	1
garnet lampfish	*Stenobrachius nannochir*	>0.04	--
ribbon barracudina	*Arctozenus risso*	0.01	8
barracudina unidentified	Paralepididae	--	2
blackbelly eelpout	*Lycodes pacificus*	--	2
barbled dragonfish unidentified	Stomiidae	--	4
popeye blacksmelt	*Lipolagus ochotensis*	--	6
rockfish unidentified	*Sebastes* sp.	--	>4
sea cockroach unidentified	Isopoda	--	--
fish unidentified	Osteichthyes	--	5

Table 11. Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl	Length	Otoliths	Fish Weight	Maturity	Stomachs Collected	Gonads	Fin Clips	Liver and Gonad RNA
1	399	57	57	57	5	3	48	2
2				trawl aborted				
3	594	59	59	59	4	2	6	2
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6				trawl aborted				
7	212	45	45	45	5	4	20	1
8	212	51	51	51	5	0	20	0
9	173	46	46	46	5	0	23	0
10	277	47	47	47	5	4	18	2
11	287	50	50	50	5	4	20	3
12	219	51	51	51	5	1	19	0
13	303	48	48	48	5	3	20	3
14	52	0	0	0	0	0	0	0
15	388	46	46	46	5	3	20	2
16	1	1	1	1	0	0	0	0
17	306	36	36	36	5	7	20	4
18				trawl aborted				
19	356	54	54	54	5	0	15	0
20	321	50	50	50	0	2	48	2
21				trawl aborted				
22	349	55	55	55	5	3	48	4
23	0	0	0	0	0	0	0	0
24	322	52	52	52	5	4	48	4
25	334	50	50	50	5	2	48	2
26	415	47	47	47	5	2	47	2
27	235	50	50	50	5	2	48	2
28	139	50	50	50	5	2	48	2
29	326	50	50	50	5	2	48	2
30	441	50	50	50	5	2	48	2
31	330	50	50	50	5	1	48	1
32	89	50	50	50	5	2	48	2
33	403	50	50	50	5	1	48	1
34				trawl aborted				
35	438	54	53	54	5	1	48	1
36	468	50	50	50	5	1	48	1

Table 11 (continued). Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl	Length	Otoliths	Fish Weight	Maturity	Stomachs Collected	Gonads	Fin Clips	Liver and Gonad RNA
37	245	50	50	50	3	2	48	2
38	373	50	50	50	5	2	48	2
39	113	51	51	51	5	0	48	0
40	323	48	48	48	5	2	48	2
41	42	42	42	42	5	0	42	0
42	292	51	51	51	5	2	48	2
43	26	26	26	26	5	3	26	2
44	9	9	9	9	4	2	9	2
45	381	50	50	50	5	2	48	2
46	366	50	50	50	5	2	48	2
47	235	50	50	50	5	2	48	2
48	343	51	51	51	5	2	48	2
49	368	50	50	50	5	2	48	2
50	215	50	50	50	5	2	48	2
51	182	50	50	50	5	1	48	1
52	187	50	50	50	5	0	48	0
53	371	51	51	51	4	2	48	2
54	381	51	51	51	5	2	48	2
55	285	50	50	50	5	2	48	2
56	83	51	51	51	5	0	48	0
57	276	50	50	50	5	2	48	2
58	1	1	1	1	0	0	1	0
59	184	49	49	49	5	1	48	1
60	238	54	54	54	5	8	48	7
61	184	39	39	39	5	10	39	10
62	46	46	46	46	5	7	46	7
63	323	52	52	52	5	8	48	7
64	42	42	42	42	5	1	42	1*
65	302	50	50	50	5	1	48	1
66	186	49	49	49	5	0	48	0
67	332	43	43	43	5	0	43	0
68				trawl aborted				
69	338	45	45	45	5	2	45	1
70	232	45	45	45	0	1	45	0
71	282	44	44	44	5	0	44	0
72	0	0	0	0	0	0	0	0

Table 11 continued. Numbers of Pacific Hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl	Length	Otoliths	Fish Weight	Maturity	Stomachs Collected	Gonads	Fin Clips	Liver and Gonad RNA
73	377	35	35	35	5	0	35	0
74				trawl aborted				
75				open codend				
76				open codend				
77				open codend				
78				open codend				
Totals	16,552	2,874	2,873	2,874	285	131	2,441	114

* A gonad sample was collected, but no liver sample

Table 12. Numbers of Pacific hake biological samples and measurements collected on the Canadian chartered F/V *Nordic Pearl* during the 2019 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

Trawl	Length	Otoliths	Fish Weight	Maturity	Stomachs Examined	Fin Clips	Gonads
1	338	46	46	46	27	40	4
2	26	26	26	26	26	26	0
3	370	61	61	61	27	40	2
4	284	56	56	56	27	40	4
5	222	56	56	56	25	40	4
6	368	56	56	56	27	40	3
7	0	0	0	0	0	0	0
8	365	52	52	52	28	40	2
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	1	1	1	1	1	1	0
12	0	0	0	0	0	0	0
13	1	1	1	1	1	1	0
14	1	1	1	1	1	1	0
15	0	0	0	0	0	0	0
16	19	19	19	19	19	19	0
17	0	0	0	0	0	0	0
18	1	1	1	1	1	1	1
19	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
22	15	15	15	15	15	15	3
Totals	2,011	391	391	391	225	304	23

References

Berger, A. M., A. M. Edwards, C. J. Grandin, and K. F. Johnson. 2019. Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2019. Prepared by the Joint Technical Committee of the U.S. and Canada Pacific hake/Whiting Agreement. National Marine Fisheries Service, Seattle, and Fisheries and Oceans Canada, Nanaimo, British Columbia.

Demer, D. A., L. Berger, M. Bernasconi, E. Bethke, K. Boswell, D. Chu, R. Domokos, A. Dunford, S. Fässler, S. Gauthier, L. C. Hufnagle, J. M. Jech, N. Bouffant, A. Lebourges-Dhaussy, X. Lurton, G. J. MacAulay, Y. Perrot, T. Ryan, S. Parker-Stetter, S. Stienessen, T. Weber, and N. Williamson. 2015. Calibration of acoustic instruments. ICES Cooperative Research Report No. 326. International Council for the Exploration of the Sea, Copenhagen.

Fleischer, G. W., K. D. Cooke, P. H. Ressler, R. E. Thomas, S. K. de Blois, L. C. Hufnagle, A. R. Kronlund, J. A. Holmes, and C. D. Wilson. 2005. The 2003 integrated acoustic and trawl survey of Pacific hake, *Merluccius productus*, in U.S. and Canadian waters off the Pacific coast. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-65.

Journel, A. G., and Ch. J. Huijbregts. 1978. Mining geostatistics. Academic Press, San Diego.

Rivoirard, J., J. Simmonds, K. G. Foote, P. Fernandes, and N. Bez. 2000. Geostatistics for estimating fish abundance. Blackwell Science, Oxford.

Sherman, K. 1991. The large marine ecosystem concept: Research and management strategy for living marine resources. Ecological Applications 1:349–360.

Simmonds, J., and D. MacLennan. 2005. Fisheries acoustics: Theory and practice, second edition. Blackwell Science, Oxford.

U.S. Secretary of Commerce
Wilbur L. Ross, Jr.

Acting Under Secretary of Commerce
for Oceans and Atmosphere
Dr. Neil Jacobs

Assistant Administrator for Fisheries
Chris Oliver

February 2020

fisheries.noaa.gov

OFFICIAL BUSINESS

National Marine
Fisheries Service
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112