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The 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey: Cruise Report SH-23-06

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National Oceanic and Atmospheric Administration
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The 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey: Cruise Report SH-23-06

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Acknowledgments

Thanks go to the officers and crew of the NOAA Ship *Bell M. Shimada* and the Canadian Coast Guard Ship *Sir John Franklin* for their contribution to the successful completion of the 2023 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 (Fishery Resource Analysis and Monitoring Division and Conservation Biology Division), Fisheries and Oceans Canada (Institute of Ocean Sciences), University of Washington (Applied Physics Laboratory and eScience Institute), NOAA's Teacher at Sea Program, Oregon State University, and numerous volunteers.

This survey was conducted under the authority of the following permits:

- California Department of Fish and Wildlife Scientific Collecting Permit, Specific Use S-210270001-21034-001, and a Memorandum of Understanding for Incidental Take.
- Oregon Department of Fish and Wildlife 2023 – Scientific Taking Permit – Fish #27280.
- Alaska Department of Fish and Game Aquatic Resource Permit No. CF-23-062.
- ESA Section 7(a)(2) Biological Opinion WCR-2016-5783.
- NMFS Determination of Take Authorization under a Biological Opinion 16335-4R.
- NMFS West Coast Region Scientific Research Permit SRP-09-2023.
- NOAA National Marine Sanctuary Research Permit MULTI-2021-008.

The *Shimada* also obtained clearance to enter Canadian waters.

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 (2014–23), coastwide annual harvests averaged 338,606 metric tons (mt; Grandin et al. 2024), with U.S. and Canadian catches averaging 275,957 mt and 62,648 mt, respectively. In 2023, the coastwide catch was 263,981 mt. The total economic impact of the hake fishery on the U.S. West Coast in 2021 was $335 million in income and 4,450 U.S. jobs. 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 such 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 United States and Canada since 1977, when the Alaska Fisheries Science Center (AFSC) started conducting triennial IAT surveys in U.S. and Canadian waters (Fleischer et al. 2005). 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 AFSC to the Northwest Fisheries Science Center (NWFSC), and the survey frequency was increased from triennial to biennial. In addition, since 1995 the United States and Canada have collaborated in assessing hake: the triennial IAT surveys of 1995, 1998, and 2001 were conducted jointly by AFSC and DFO, and IAT surveys since 2003 have been conducted jointly by NWFSC and DFO. Age- and sex-specific estimates of total population abundance derived from the IAT surveys are a key fishery-independent data source for the joint U.S.–Canada hake stock assessment. A time series of survey estimates of hake abundance and age composition is used in an age-structured assessment model, which ultimately acts as a foundation for advice on U.S., tribal, and international harvest levels.

The results presented here are from the 2023 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 NWFSC and the Institute of Ocean Sciences at DFO conducted the 2023 IAT survey aboard the NOAA Ship *Bell M. Shimada* (hereafter, "the *Shimada*")—a 209 ft acoustically quieted Fisheries Survey Vessel—and the Canadian Coast Guard Ship *Sir John Franklin* (hereafter, "the *Franklin*"), a 208 ft Offshore Fishery Science Vessel. Both vessels are stern trawlers equipped for fisheries and oceanographic research.

The survey began at Point Conception, California (the current southern extent of the survey area), and proceeded north along the west coast of the United States and Canada, surveying Queen Charlotte Sound, Hecate Strait, Dixon Entrance (the northern extent of the survey area), and the west side of Haida Gwaii, which was surveyed from north to south (Figure 1). Acoustic transects were oriented east–west (except for transects in Dixon Entrance, which had a north–south orientation), extended from the 50 m isobath (or as close to that depth as was safely navigable) to the 1,500 m isobath, and were spaced 10 nautical miles (nmi) apart through Transect 100 (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 not only that the full extent of the hake coastal population was accounted for in the survey area, but also 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 EK80 wideband transceiver (WBT) scientific echosounder system that operated with an EK80 software system in a CW (continuous wave or narrowband) pulse transmission mode; FM (broadband or wideband) mode was not used. The *Franklin* also collected acoustic data with a Simrad EK80 system; six Simrad split-beam transducers, operating at 18, 38, 70, 120, 200, and 333 kHz, were mounted on a drop-keel that positioned the transducers at a depth of 4.5 m below the water surface.

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 ADCP was not operational and 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 EK80 and the *Shimada*'s Simrad ES60 system.

Calibration

The *Shimada*'s acoustic system was calibrated in the field before and after the survey; the *Franklin*'s acoustic system was calibrated before the survey. Calibration locations were chosen based on past successful calibrations, 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. Both the *Shimada* and the *Franklin* anchored from the bow for calibration. The calibration procedure involved suspending a metal sphere with a known backscattering cross-section 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 *Franklin*, 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* and the *Franklin* maintained a vessel speed of up to approximately 10 knots (kn) during acoustic operations along each transect and cross-transect. Running of acoustic transects occurred only between sunrise and sunset when hake formed identifiable midwater layers. Acoustic data, however, were collected day and night.

Narrowband (CW) EK80 acoustic backscatter data were collected on the *Shimada* to a maximum depth of approximately 750 m for the 18 , 38 , 70 , and 120 kHz transducers, and 300 m for the 200 kHz transducer. The depths to which acoustic backscatter data were collected on the *Franklin* varied, based on bottom detection. Raw acoustic backscatter (EK80 .raw) data files were logged from all frequencies. Acousticians used the raw files for live viewing and for scrutinizing on laptop PCs with Echoview (version 13.1.120; Echoview Software Pty Ltd.). Event log markers and other marks, including at-sea judgments of hake backscattering layers, were made on the live-viewed files. While all EK80 frequencies could be used for at-sea judgments, 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 [Euphausiacea].)

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 made 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

The *Shimada* conducted daytime trawls with a NET Systems Aleutian Wing 24/20 midwater trawl (AWT). This net has a vertical opening that averaged 26 m (range: 18–34 m) and a headrope and footrope of 101.7 m each. Overall length of the AWT is 142 m. A 1¼-inch (32 mm) codend liner was used. The AWT was deployed with a pair of 4 m^2, 884.5 kg Super V "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; the trawl sonar also helped scientists to approximately gauge the catch quantity and to know when the AWT was in targeted sign. A Samsung Galaxy Tab Active 3, running an app created in-house with Android Developer, was used to record net mensuration details. On the *Franklin*, daytime trawling was also performed with an AWT 24/20 but with a smaller codend liner (¼-inch, 6.35 mm) and USA Jet doors instead of "Fishbusters." The *Franklin* also conducted Bongo tows with a 250 µm Bongo net.

To provide additional biological ground truthing (i.e., provide information on the biological composition of multiple scattering layers in the water column), the AWT on the *Shimada* was deployed with one of two different camera systems:

1. A stereo camera system (Semi-Autonomous Strobed Stereo Imager, SASSI) consisted of two pressure housings, one for the system's two cameras and one for the battery, as well as four smaller housings for LED lights (built by the University of Washington's Advanced Physics Lab and set in a strobed mode) that were attached to an aluminum frame. Two Teledyne FLIR Blackfly GigE cameras (one color and one monochrome) were controlled by an UDOO X86 Advanced Plus single-board computer via control boards built by AFSC. The battery was a set of two nickel metal hydride (NiMH) cells capable of being removed and charged. The camera frame was attached to the inside of the AWT and sewn in, approximately 10 m forward of the codend and facing port to starboard. Stereo camera footage was stored on a 120 GB solid-state drive and transferred after every trawl via an Ethernet connection.

2. A SpyTec Mobius camera and light setup was mounted to the top panel of the AWT intermediate section, approximately 20 m forward of the codend. This camera faced aft along the net toward the codend. Three custom pressure housings were mounted inside a high density polyethylene (HDPE) frame (all made by Sexton Corporation). 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 32 GB 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 39plus 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 soon after a trawl was completed and notes were recorded onto a spreadsheet.

Similarly, the AWT on the *Franklin* was equipped with a digital video camera system mounted inside the net. 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 approximately 10 m ahead of the codend section (which was 9.7 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.

Sorted portions of the catch were weighed to the nearest 0.05 kg with an electronic, 60 kg capacity Marel M1100 PL4200 motion-compensating scale. 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 millimeter with an Ichthystick board made by AFSC.

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 conductivity–temperature–depth (CTD) stations; water extracted from the Niskin bottles was filtered in support of environmental DNA (eDNA) and RNA (eRNA) work. Additional eDNA water samples were collected opportunistically from the flow-through system when marine mammals were sighted nearby; these samples were stored for later filtration. Vertical zooplankton tows were conducted with a 0.5 m vertical ring net (mesh size: 202 µm) and attached flowmeter.

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 backscatter that were indicative of high densities of hake. Trawling on weaker backscatter was also conducted to confirm or deny the presence of hake. Hake aggregations were targeted for trawling along the entire survey area; ideally, no more than three or four transects were run without conducting a trawl.

Prior to commencing trawl operations, marine mammal protocols were followed on the *Shimada* and the *Franklin* to ascertain that no marine mammals were within 500 m of the vessel 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 3 kn. Individual trawl durations varied, lasting only long enough to ensure that an adequate sample (i.e., a minimum of approximately 350 hake) was obtained. When targeted backscatter was light, however, trawl durations necessarily increased, lasting up to 20–30 minutes. The scientist overseeing trawl operations on the bridge determined the trawl duration based on the quantity of fish and other organisms that the third-wire 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 AFSC and modified by the Fisheries Engineering and Acoustic Technologies (FEAT) team within FRAM, 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 accurately 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 hake 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. With regards to nonhake species, lengths were taken from all rockfish, squid, and any species that were dominant in the catch composition. Ovaries were collected from select rockfish species. Lastly, a variety of species were frozen whole for a mix of special project requests, e.g., whole hake (both adult and young-of-the-year) for detecting the presence of chemical tracers.

Zooplankton sampling on the *Shimada* was conducted along select acoustic transects at bottom depths of 60, 150, 300, 500, 1,000, and 1,500 m. The ship held station while the ring net was towed vertically. 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 and analyzed back on land. Bongo tows conducted on the *Franklin* consisted of a vertical profile down to 250 m.

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 39plus temperature and pressure recorders to the AWT headrope kite and underwater camera system during trawls, and by deploying an Oceanscience UnderwayCTD (UCTD) while the vessel was moving. 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 *Franklin*, RBR*duet*^{3} T.D dual-channel loggers that measured pressure and temperature were used on both the trawl's headrope and camera cage. CTD casts were also conducted on the *Franklin*, with or without being housed in a rosette.

Operations

Physical oceanographic sampling was conducted day and night on the *Shimada*. CTD casts were performed at night at predetermined locations along acoustic transects, in conjunction with zooplankton sampling stations, and when the acoustic system was calibrated. UCTD casts were conducted at predetermined stations during daytime operations while the ship was underway and collecting acoustic data. 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

Two calibrations of the *Shimada*'s EK80 acoustic system were conducted: the first on 26 June offshore of Monterey, California, and the second on 9 September in Elliott Bay, Washington. Results from both calibrations (Table 1) were within expected levels based on factory settings and results from previous calibrations. The *Franklin*'s acoustic system was calibrated on 17 August in Saanich Inlet, Vancouver Island. Calibration results for the *Franklin* were also within expected levels.

Acoustic Sampling and Pacific Hake Distribution

The *Shimada* surveyed between 27 June and 5 September (Table 2), collecting acoustic data from 70 transects (Figure 1, Table 3) between Transect 1 (Point Conception) and Transect 76 (Grays Harbor, Washington) and from 15 transects between Transect 88 (near Tofino, British Columbia) and Transect 102 (Queen Charlotte Sound), for a total linear distance of 3,027 nmi. The *Franklin* surveyed between 19 August and 10 September, collecting acoustic data from 11 transects (Table 4) between Transect 77 (Copalis Beach, Washington) and Transect 87 (Barkley Sound, British Columbia) and from 20 transects between Transect 103 (southern Hecate Strait) and Transect 111 (Dixon Entrance), then south along the west coast of Haida Gwaii to Transect 122, for a total linear distance of 1,184 nmi. The *Shimada* dropped six transects (four off California, two off Oregon) to make up for time lost due to the delay in starting the survey; the *Franklin* did not drop any transects.

The *Shimada* made adjustments to five transects during the survey. To avoid oil platforms, the middle of Transect 1 was shifted south roughly 0.4 nmi and the inshore, beginning portion of Transect 2 was shifted north roughly 1.7 nmi. The central portion of Transect 21 was shifted north to avoid the South Farallon Islands, the eastern portion of Transect 99 was shifted south approximately 1.5 nmi to avoid shallow waters surrounding the Scott Islands, and all of Transect 101 was shifted 2.0 nmi south to avoid going through a marine protected area (MPA).

Nine transects (21–23, 27, 37–39, 40, and 53) were extended further west to map the offshore extent of hake sign; most transect extensions were between San Francisco, California, and Humboldt Bay, California. The total linear distance of the extensions was slightly over 111 nmi and the average extension was 12.4 nmi. Transects 37 and 39 were extended the most (34.4 and 39.0 nmi, respectively).

Adult hake were observed on 69 transects (Figure 2), ranging from Transect 5 off Pismo Beach, California, to the midpoint of Vancouver Island, by Nootka Sound (Transect 91). The *Shimada* observed adult hake consistently between Transects 13 and 75; only three transects (15, 34, and 72) in that range had no adult hake. Areas of strongest adult hake sign were observed along northern California and southern Oregon from south of Cape Mendocino north to Coos Bay. A band of adult hake was also observed by Newport, Oregon, and Heceta Bank, as well as off San Francisco, extending north for some 80 nmi. Concentrations of adult hake south of San Francisco were relatively light (seven transects had no hake) save for localized areas such as off Monterey. Comparatively little adult hake sign was observed along northern Oregon. Off Washington, the *Shimada* and the *Franklin* observed even less adult hake sign save for two clusters off the northwestern tip of Washington; such low amounts were uncharacteristic for this portion of the U.S. coast. The two vessels observed a narrow band of relatively weak adult hake sign off the southern half of Vancouver Island, but further north the *Shimada* and *Franklin* observed no adult hake in Canadian or southeastern Alaskan waters.

Biological sampling

The *Shimada* successfully conducted 62 midwater trawls during the survey, the *Frankli*n 29 (Figure 3, Tables 5 and 6). Trawl 44 on the *Shimada* was conducted with an open codend and the first two trawls the *Franklin* conducted were test trawls. On the *Shimada*, the average duration of trawls that performed properly was 15.5 minutes (range: 2.9–37.3); 87% ($n = 53$) were shorter than 25 minutes and almost half (49%) were shorter than 15 minutes. Only four trawls, which typically targeted weaker or more diffuse offshore sign, were longer than 30 minutes. Of these four, Trawl 58's duration of over 61 minutes was an outlier given that hydraulics on the *Shimada*'s net reel blew while the AWT was being deployed and the net then fished at a different target depth while repairs were being made. Average trawl depth on the *Shimada* was 300 m (range: 134–480). Most trawls (81%, $n = 50$) were conducted between 200 and 450 m; only 8% of trawls ($n = 5$) were shallower than 150 m and only 3% ($n = 2$) were deeper than 450 m. Over half of all trawls conducted on the *Shimada* (53%, $n = 33$) were within 100 m of the bottom; 12 trawls (19%) were in excess of 300 m off bottom. On the *Franklin*, average trawl duration was 22 minutes (range: 5–34); over half (54%) were 20–30 minutes long. Like the 61-minute trawl on the *Shimada*, the 62-minute trawl on the *Frankli*n (Trawl 13) was an outlier given that the net, after fishing at a target depth of 225 m, was lowered to a depth of 620 m so that warps could be rewrapped on the drums. Average trawl depth on the *Franklin* was 226 m (range: 82–456); 59% of the trawls were between 100 and 250 m.

Two trawls on the *Shimada* were aborted because marine mammals were within 500 m of the vessel and three trawls were aborted because of gear issues. The *Shimada* also abandoned three fishing sites because of marine mammals within 500 m of the vessel, one site because of fishing gear in the water, and another site because of unacceptable bottom topography at the aim point location. One trawl on the *Franklin* was aborted because of gear issues; two attempts to trawl were abandoned because of marine mammals within 500 m of the ship.

The *Franklin* experienced a marine mammal "take" at the conclusion of the second test trawl conducted 18 August, roughly 23 nmi off the Washington coast. When the net was retrieved, two dead Pacific white-sided dolphins (*Lagenorhynchus obliquidens*) were found in the net. Prior to setting the net, the *Franklin* had completed a 10-minute marine mammal watch and no marine mammals had been seen. During the trawl, dolphins were sighted within a mile of the vessel. At the time of haul back, there were no marine mammals within a mile of the *Franklin*. No photos were taken of the dead dolphins and the bodies were not kept.

Of the 62 trawls that the *Shimada* conducted, 57 (92%) caught hake. Hake catch weights ranged from 0.3 kg to 1,077.1 kg, with an average of 183 kg, although 54% of hake trawls caught less than 100 kg of hake. Nonhake catch weights ranged from 1.4 kg to 1,617.4 kg, with an average of 70 kg. Two aborted trawls on the *Shimada* (Trawls 3 and 57) caught token amounts of nonhake species. Of the 27 trawls targeting echosign that the *Franklin* conducted, nine (33%) caught hake and all caught nonhake species; hake catch weights ranged from 1.2 kg to 304.6 kg and nonhake catch weights ranged from 5.3 kg to over 10 mt. Aborted Trawl 21 caught eight nonhake species.

Hake was the dominant species caught in the trawls that the *Shimada* conducted in U.S. waters (Table 7), accounting for 82% of catch composition by weight. Two species of rockfish (yellowtail [*Sebastes flavidus*] and Pacific ocean perch [*S. alutus*]) together accounted for the next 10% of catch composition by weight. Large numbers of pyrosomes (Pyrosomida) and lanternfish (Myctophidae) were caught, even though by weight they accounted for only 2% of catch composition by weight. Relatively large numbers of northern anchovy (*Engraulis mordax*), salps (Salpida), and glass shrimp (*Pasiphaea pacifica*) were also caught. In Canadian waters (Table 8), the *Shimada* caught mostly rockfish—the top six rockfish species accounted for 84% of catch composition by weight. Hake accounted for only 7%. Relatively large numbers of lanternfish and glass shrimp were caught.

On the *Franklin*, hake accounted for only roughly 4% of catch composition, by weight, of trawls conducted in U.S. waters (Table 9); yellowtail rockfish and widow rockfish (*Sebastes entomelas*) together accounted for 88% (most of which came from Trawl 6 on Transect 82). In Canadian waters (Table 10), even less hake was caught, by weight (3%). Over 50% of catch composition consisted of yellowtail rockfish, followed by walleye pollock (*Gadus chalcogrammus,* 16%) and splitnose rockfish (*Sebastes diploproa,* 14%). In both U.S. and Canadian waters, the *Franklin* caught relatively large numbers of Pacific herring (*Clupea pallasi*).

Between the *Shimada* and the *Franklin*, more than 14,500 hake were measured for length and more than 2,550 pairs of hake otoliths were collected (Tables 11 and 12). Hake stomachs were examined on both vessels, but only on the *Shimada* were hake stomachs, livers, and gonads sampled for future lab analysis. Thirty-four yellowtail rockfish ovaries (from Trawls 49, 56, and 58–63), as well as two canary rockfish (*Sebastes pinniger*) ovaries (Trawl 63) were collected on the *Shimada*. Raw length–frequency distributions (Figure 4) were characterized by U.S. hake displaying a widely spaced multimodal distribution, with age-1 hake centered on 21 cm and age-2+ hake displaying modes at 27, 34, and 42 cm. Age-0 hake, with a mode at 9 cm, were distinctly separate from the older hake and quite prevalent. Hake in Canada consisted primarily of larger fish between 40 and 64 cm, with a mode at 49 cm. As the survey progressed north, hake lengths steadily got larger (Figure 5). Hake specimens collected during the survey ranged in age from 1 to 18 years (Figure 6); age-2 hake (2021 year-class) and age-3 hake (2020 year-class) were the dominant age classes observed, followed by age-7 hake (2016 year-class), age-1 hake (2022 year-class), and age-9 hake (2014 year-class) to a lesser extent.

Pacific hake abundance estimate

Due to nonlinearity, the old Simrad EK60 system used in prior IAT surveys collected raw acoustic data (nautical area scattering coefficient, or NASC) that were consistently higher than those collected with the current EK80 system. Based on experiments conducted in 2018 that compared the EK60 with the EK80, as well as an analysis of EK60 data collected in 2019, it was found that EK60 NASC values were consistently larger than those of the EK80 by approximately 6%. To maintain a consistent biomass time series (1995–2023), total biomass estimates this year were multiplied by a factor of 1.06 so that they would compare favorably to biomass estimates had the old EK60 system still been used.

The 2023 biomass estimate of adult hake (age-2+) off the west coast of the United States and Canada totaled 0.907 million mt (Figure 7), with approximately 97.6% (0.885 mt) of observed biomass located in U.S. waters. The 2023 estimate was one of the four smallest estimates in the time series, representing a decrease of 0.618 mt (approximately 41%) from the 2021 biomass estimate and 0.816 mt (47%) from the 2019 estimate of 1.723 mt. The number of age-2 hake observed (Figure 8) was more than twice that of age-3 hake (51% vs. 25%); the difference in biomass between the two ages was less sizeable. When combined, age-2 and age-3 hake accounted for almost three-fourths of the overall 2023 biomass estimate. Age-7 and age-9 hake together contributed roughly 14% to both the numbers and biomass estimates.

Oceanographic sampling

The *Shimada* collected 255 CTD temperature and salinity profiles at selected locations along acoustic transects and at both acoustic system calibration sites (Figure 9). Only three UCTD profiles were successfully collected (two test casts as the *Shimada* transited south and one cast on Transect 2) before the UCTD probe was lost at sea during the fourth deployment; no replacement UCTD probe was available. Additional temperature profiles were collected from 102 successful SBE 39plus casts (66 with the AWT headrope kite, 31 with one of the two AWT camera systems, and five test casts). The *Franklin* collected 74 CTD profiles at the acoustic system calibration site and at selected locations along acoustic transects. The *Shimada* collected six zooplankton samples along each of the following transects, for a total of 36 stations: Transects 1 (Point Conception), 25 (Bodega Bay), 41 (Trinidad Head), 63 (north of the Newport Hydroline), 88 (Mackas Line), and 98 (Port Hardy). Also collected during U.S. Legs 1–4 on the *Shimada* and Canada Leg 1 on the *Franklin* were 2,504 eDNA samples (2,456 filtering, 36 degradation, and 12 marine mammal eDNA) and six filtered eRNA samples. On the *Shimada*, 124 HAB samples were collected. The *Franklin* also conducted 23 successful Bongo tows in Hecate Strait, Dixon Entrance, and west of Haida Gwaii.

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Figures

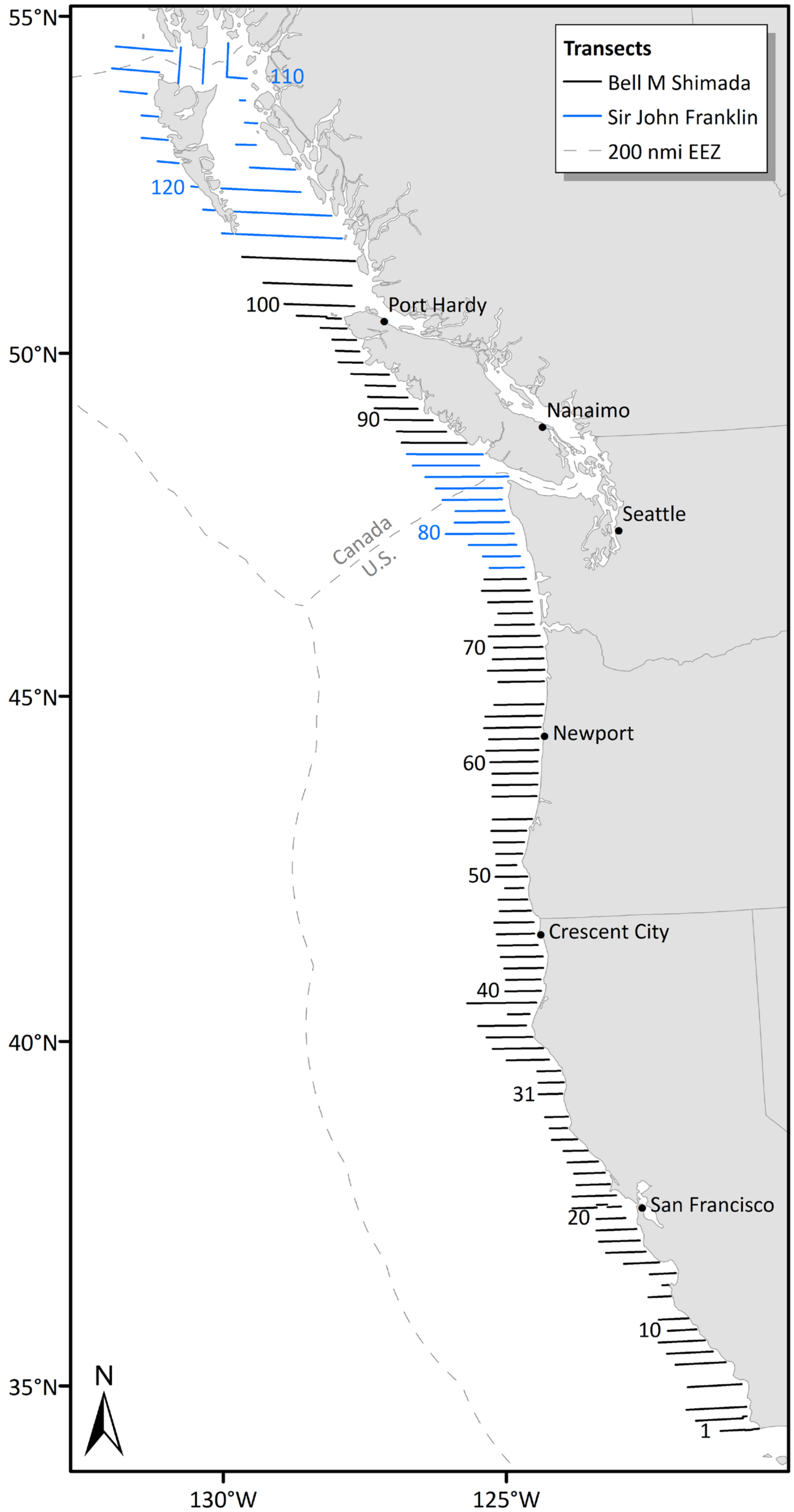

Figure 1. Survey track design used during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

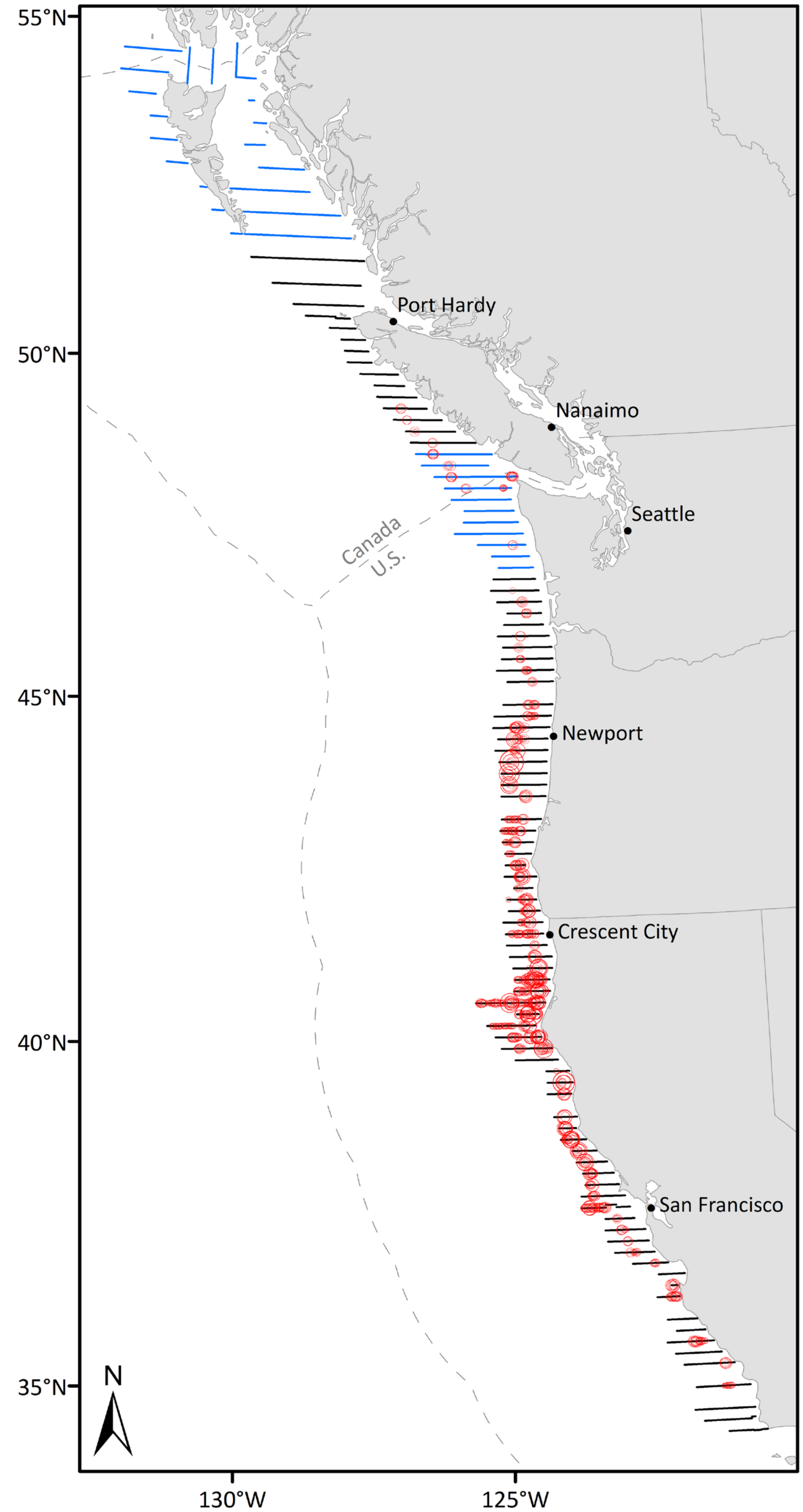

Figure 2. Acoustic area backscattering attributed to adult (age-2+) hake along transects completed during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

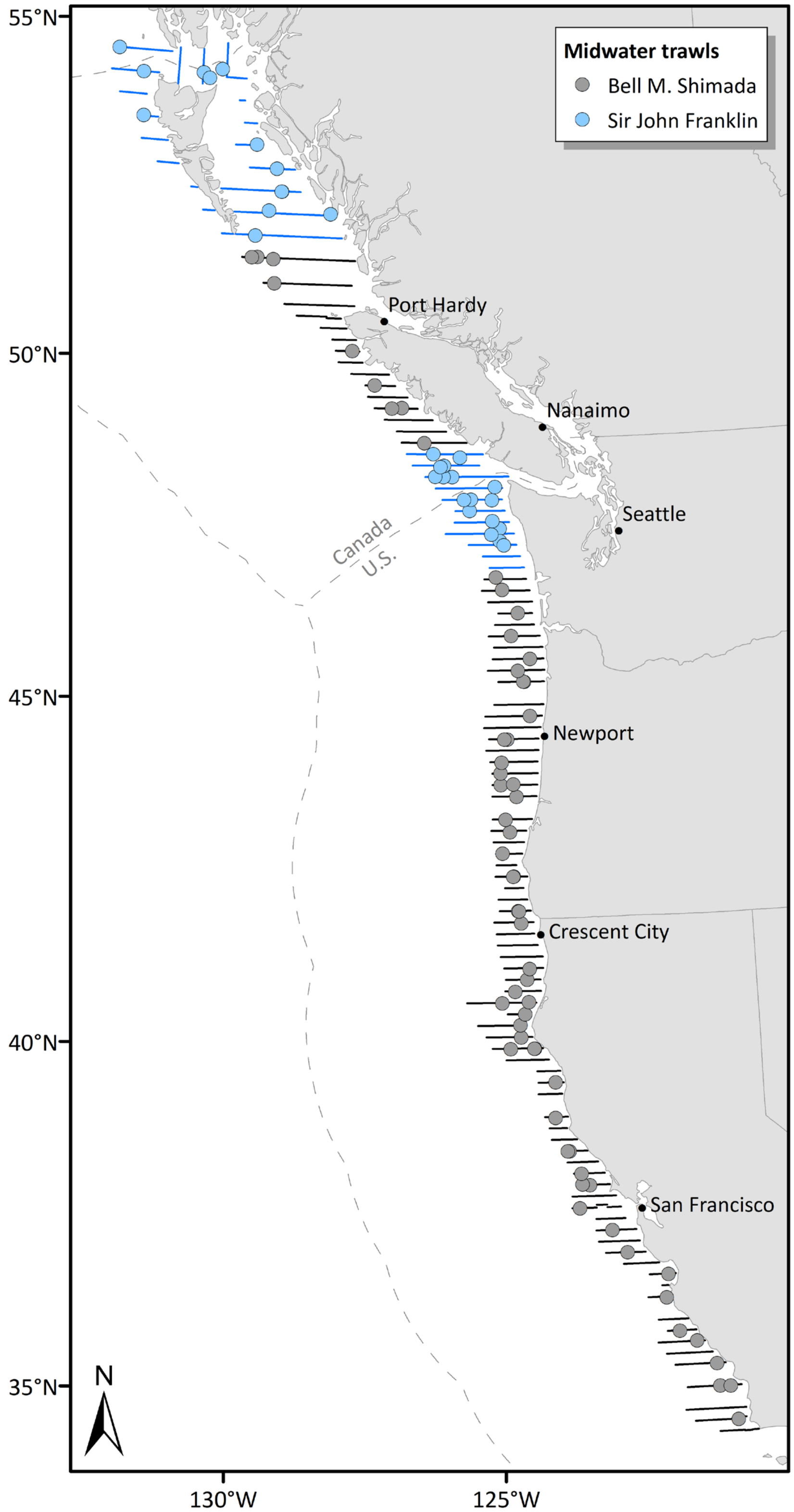

Figure 3. Acoustic transect lines and locations of midwater trawls conducted during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

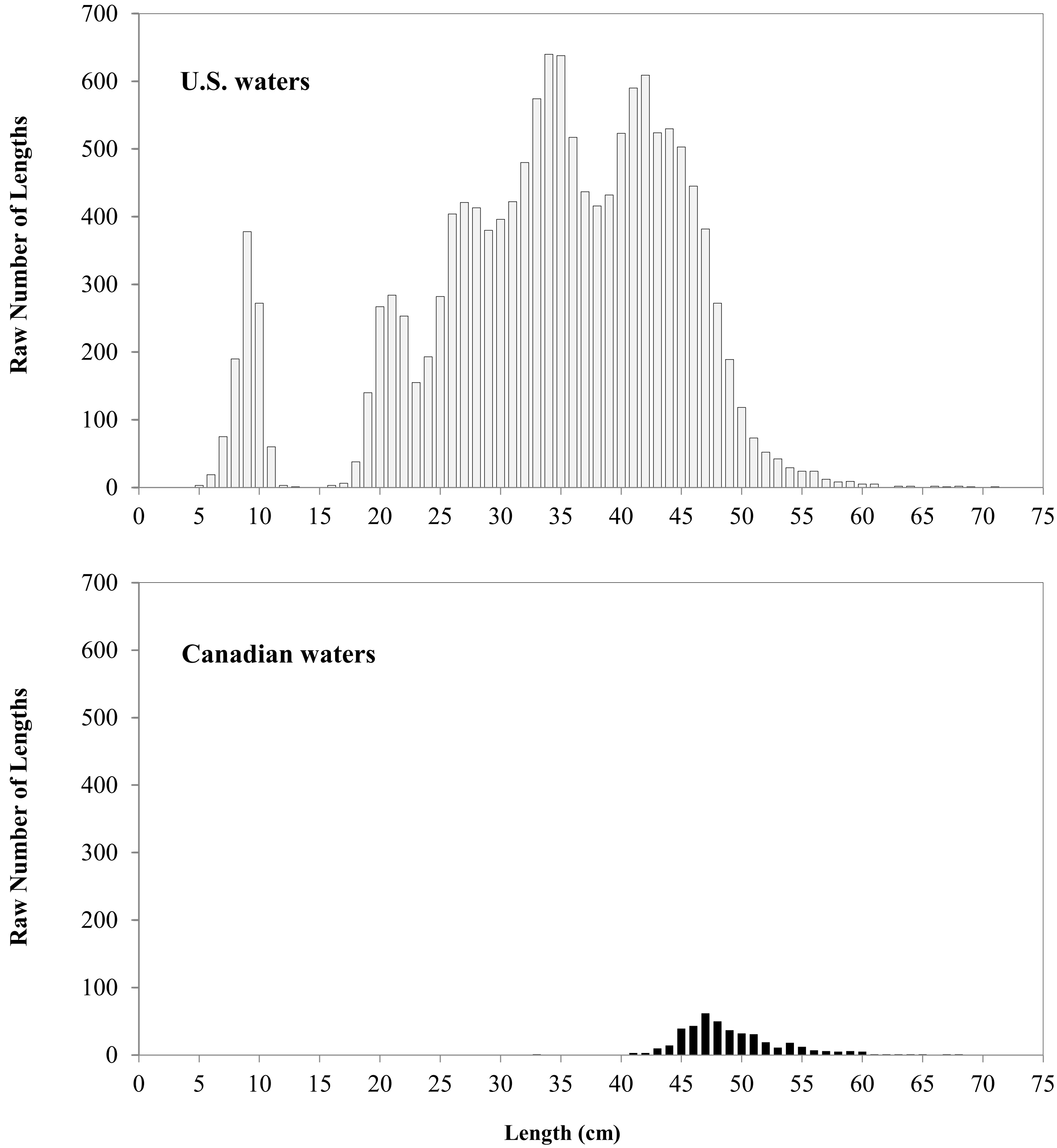

Figure 4. Raw length–frequency distributions of hake from specimens measured during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

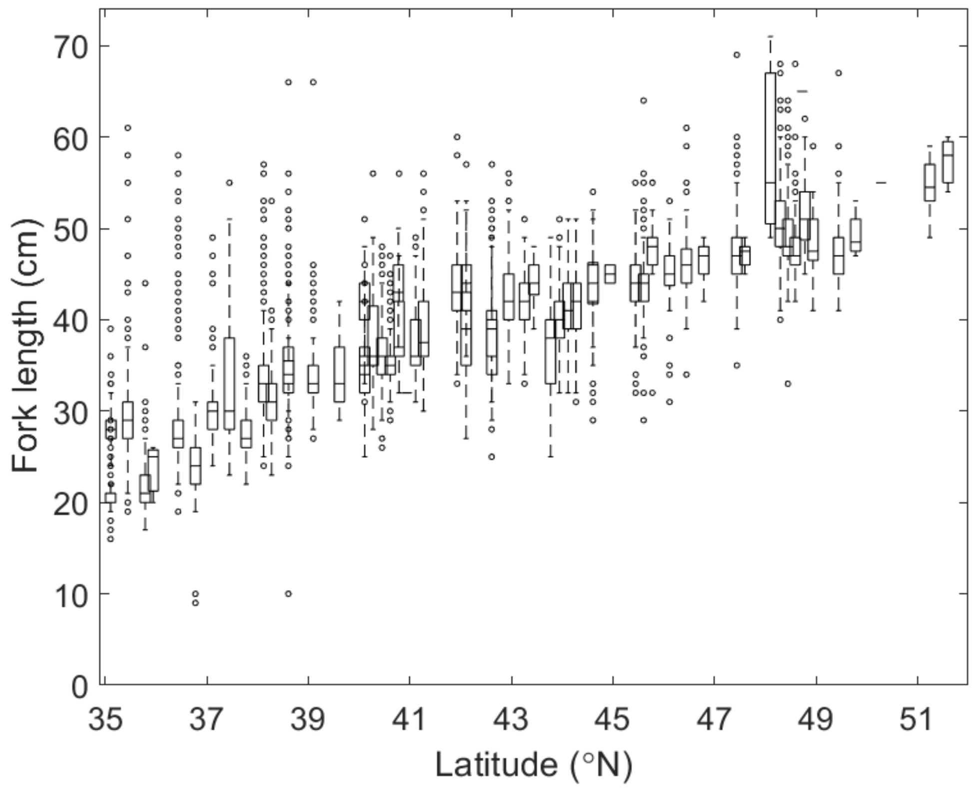

Figure 5. Box-and-whisker plot of the length–frequency distributions of hake for trawl tows conducted as part of the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey. The central box indicates the range of fish lengths in the upper and lower quartiles, with the median represented by the horizontal line in the box. The whiskers extend to 1.5 times the interquartile range, or approximately the 1st and 99th percentiles, and outliers are shown as open circles for each haul.

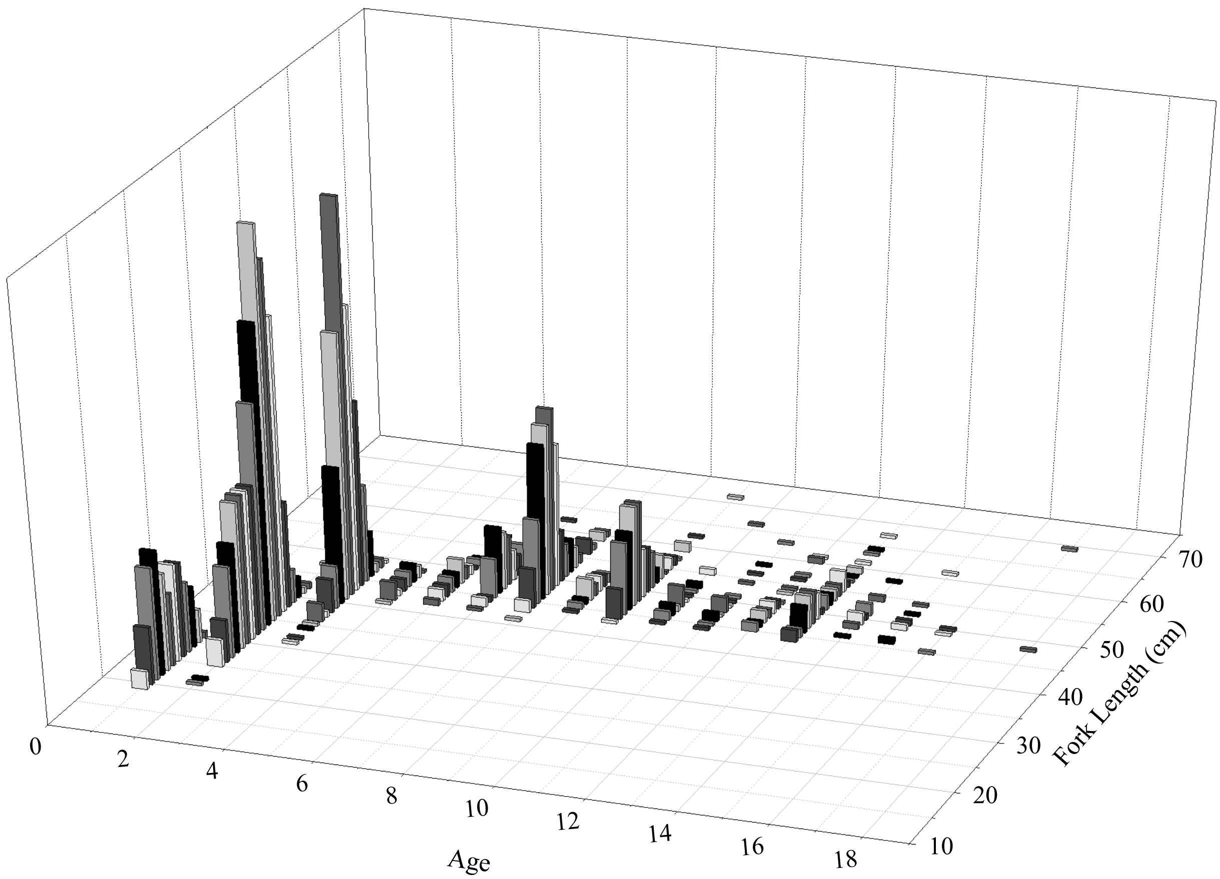

Figure 6. Age–length distribution of hake from specimens collected during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey. Ages are based on interpretation of otoliths.

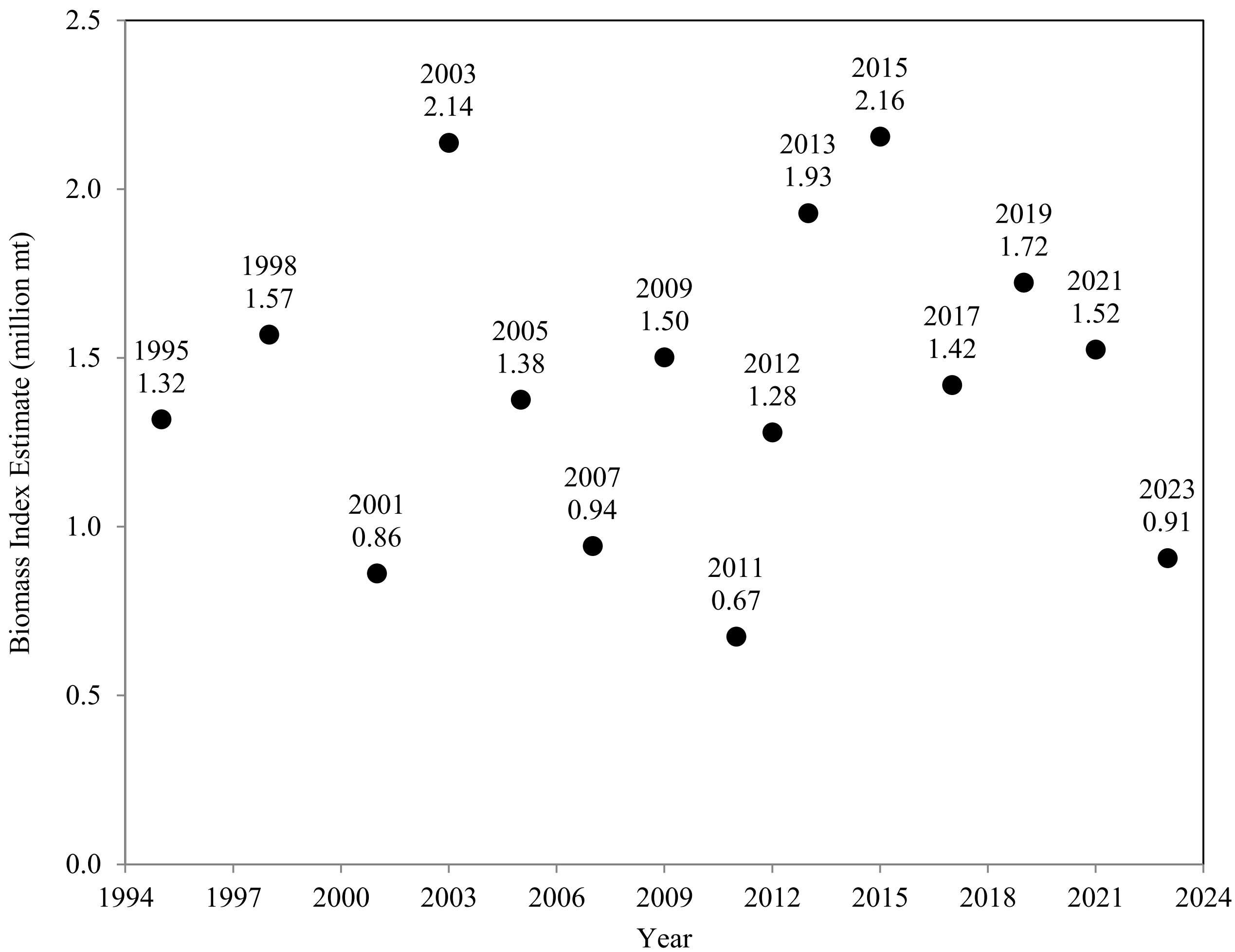

Figure 7. Coastwide biomass estimates (millions of metric tons) of adult hake (age-2+) from joint U.S.–Canada integrated acoustic trawl surveys, 1995 to 2023. Each symbol displays survey year and biomass estimate. Note: The 2021 and 2023 biomass estimates were converted from one based on the EK80 acoustic system to one based on the EK60 system. Historical biomass estimates (1995–2013) were reanalyzed in 2015 and may be different from those in previous reports.

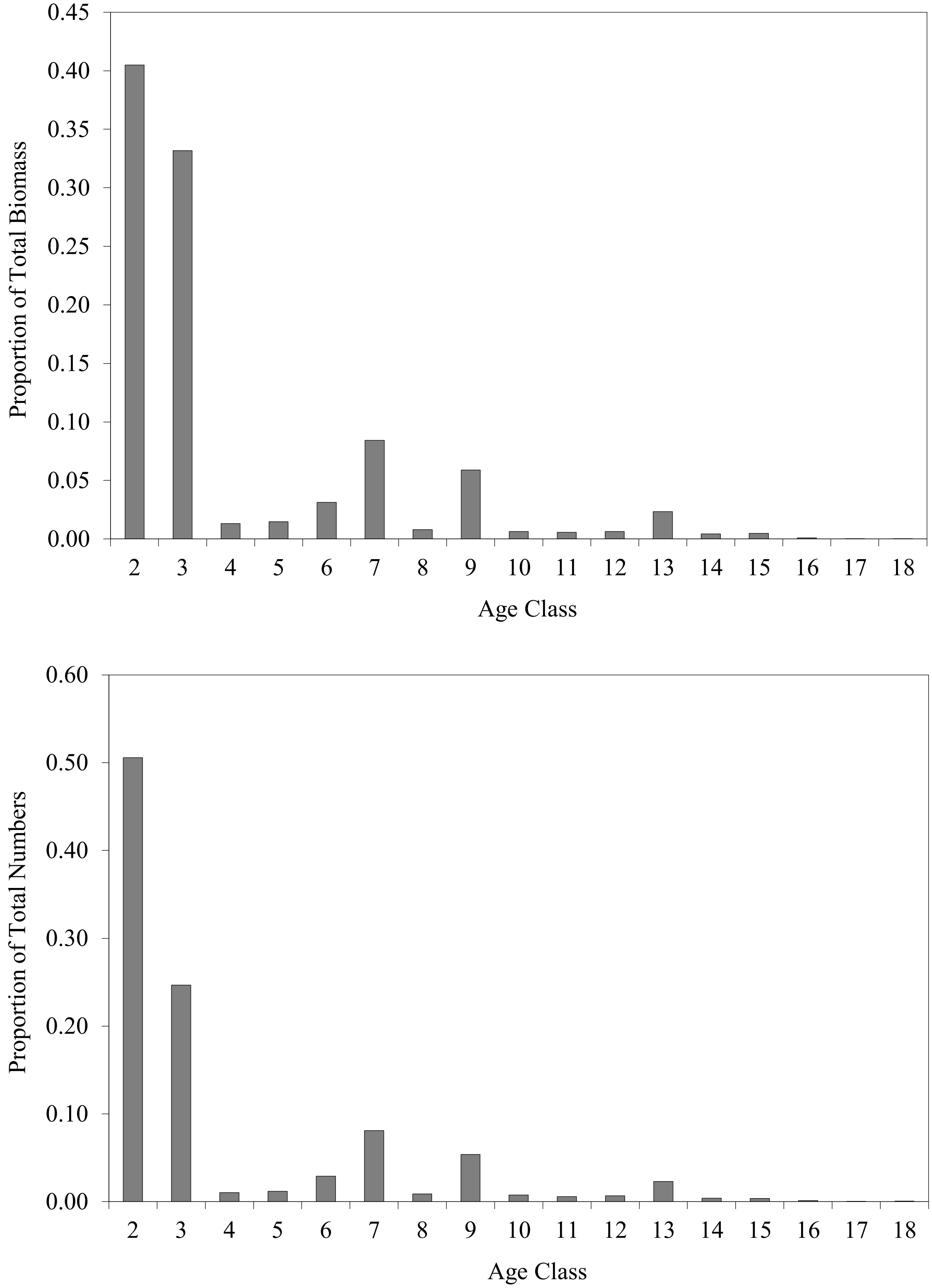

Figure 8. Acoustically weighted estimated proportions of total biomass and total numbers of adult (age-2+) hake by age class from the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

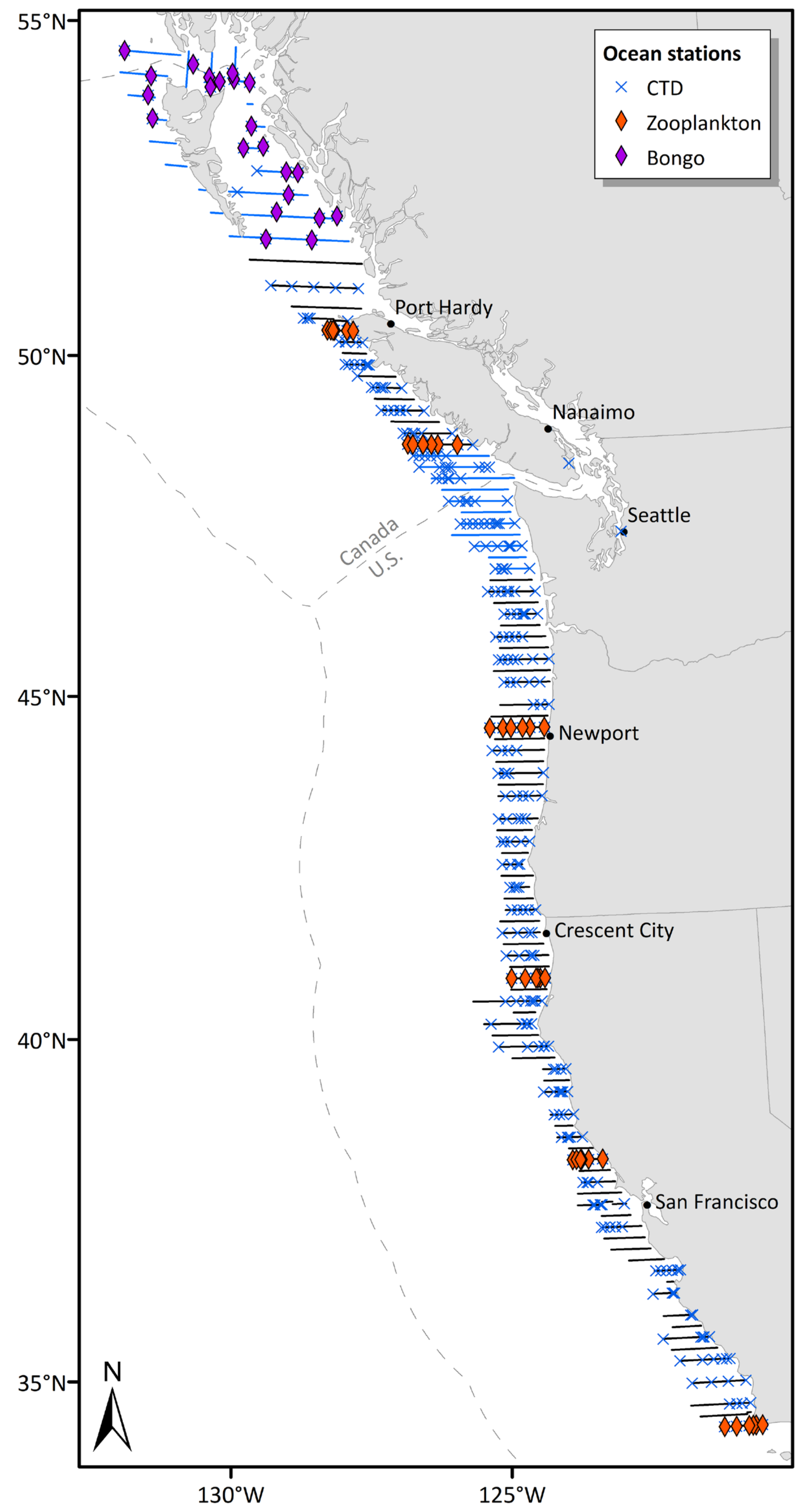

Figure 9. Locations of conductivity–temperature–depth (CTD) deployments, zooplankton sampling, and Bongo tows conducted during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Tables

Table 1. Simrad EK80 38-kHz acoustic system descriptions and settings used aboard the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey, and results from acoustic system calibrations with a standard target. Key: S_a = 10log$_{10}$ (area scattering coefficient), S_v = volume backscattering, *RMS* = root mean square.

	Survey system settings	Calibrations 26 Jun Monterey, CA	Calibrations 9 Sep Elliott Bay, WA
Transducer:	ES38B	—	—
Serial number:	30715	—	—
Transducer depth (m):	9.15	—	—
Pulse length (ms):	1.024	—	—
Transmitted power (W):	2,000	—	—
Two-way beam angle (dB):	–20.7	—	—
S_a correction (dB):	–0.07	–0.07	–0.10
System gain (dB):	26.46	26.46	26.57
3-dB beam angle (deg.)			
Alongship (Minor):	6.71	6.71	6.97
Athwartship (Major):	6.81	6.81	6.95
Angle offset (deg.)			
Alongship (Minor):	–0.20	–0.20	–0.13
Athwartship (Major):	–0.17	–0.17	–0.12
Post-processing S_v threshold (dB):	–69	—	—
Sphere range from transducer (m):	—	18–20	21
Ambient sound speed (m/s):	1,480.0	1,493.5	1,496.5
Water temperature at transducer (°C):	—	14.8	13.5
Water temperature at sphere (°C):	—	10.1	13.2
Ambient water temperature (°C):	6.9	11.4	13.4
Ambient water salinity (ppt):	33.7	33.7	33.7
RMS error (dB):	—	0.13	0.07

Table 2. Itinerary for the 2021 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Date(s)	Event(s)
U.S. Leg 1	
06/15	Personnel embark onto the NOAA Ship *Bell M. Shimada* in Newport (OR).
06/16–22	The planned departure is delayed seven days because of issues with the *Shimada*'s fast rescue boat (FRB) and a staffing shortage.
06/23	The *Shimada* leaves Newport and starts transiting south.
06/26	Personnel conduct an acoustic system calibration of the *Shimada* with a standard target offshore of Monterey (CA).
06/27	The survey starts with Transect 1 at Point Conception (CA).
06/30	The *Shimada* finishes Transect 7.
07/01	The *Shimada* pulls into San Francisco (CA).
07/02–04	Inport San Francisco; exchange personnel.
U.S. Leg 2	
07/05	The *Shimada* leaves San Francisco.
07/06	The *Shimada* resumes the survey with Transect 8.
07/17	The *Shimada* finishes Transect 34 and starts transiting north.
07/19	The *Shimada* pulls into Newport.
07/20–22	Inport Newport; exchange personnel.
U.S. Leg 3	
07/23	The *Shimada* leaves Newport and starts transiting south.
07/25	The *Shimada* resumes the survey with Transect 35.
08/04	The *Shimada* finishes Transect 55.
08/05	The *Shimada* pulls into Newport.
08/06–08	Inport Newport; exchange personnel.
U.S. Leg 4	
08/09	The planned departure is delayed one day because of issues with the *Shimada*'s refrigeration.
08/10	The *Shimada* leaves Newport and resumes the survey with Transect 57.
08/19	The *Shimada* conducts a small-boat transfer of a crew member off Astoria (OR).
08/22	The *Shimada* finishes Transect 76.
08/23	The *Shimada* pulls into Port Angeles (WA).
08/24–26	Inport Port Angeles; exchange personnel.
U.S. Leg 5	
08/27	The *Shimada* leaves Port Angeles and transits out of the Strait of Juan de Fuca.
08/28	The *Shimada* resumes the survey with Transect 88.
09/05	The *Shimada* finishes Transect 102.
09/06	The *Shimada* conducts two midwater trawls on Transect 102, then starts transiting south to Seattle (WA).
09/09	Personnel conduct an acoustic system calibration of the *Shimada* with a standard target in Elliott Bay, Seattle.
09/10	Inport Seattle; personnel disembark.

Table 2 (continued). Itinerary for the 2021 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Date(s)	Event(s)
Canada Leg 1	
08/17	Personnel embark onto the CCGS *Sir John Franklin* in Sidney (BC). The *Franklin* transits to Coles Bay, Saanich Inlet (BC), where personnel conduct an acoustic system calibration of the *Franklin* with a standard target. The *Franklin* starts transiting to the west coast of Washington.
08/18	The *Franklin* enters U.S. waters and conducts two test tows.
08/19	The *Franklin* starts surveying with Transect 77.
08/27	The *Franklin* finishes Transect 87; starts transit to Port Hardy (BC).
08/28	Touch-and-go in Port Hardy to exchange personnel; transit north.
Canada Leg 2	
08/29	The *Franklin* resumes the survey with Transect 103.
09/03	The *Franklin* finishes Transect 112.
09/04–05	Inport Prince Rupert (BC); exchange personnel.
Canada Leg 3	
09/06	The *Franklin* leaves Prince Rupert and resumes the survey with Transect 113.
09/10	The *Franklin* finishes Transect 122; starts transit south.
09/12	Personnel conduct drop-keel maintenance and noise tests in Saanich Inlet; inport Sidney; personnel disembark. End of survey.

Table 3. Coordinates and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

	Start		End		
Transect	**Lat (N)**	**Long (W)**	**Lat (N)**	**Long (W)**	**Length (nmi)**
1*	34°26.77′	121°10.77′	34°26.74′	120°44.34′	21.8
1*	34°26.37′	120°44.33′	34°26.32′	120°36.74′	6.3
1*	34°26.75′	120°36.74′	34°26.74′	120°29.59′	5.9
2*	34°38.45′	120°41.94′	34°38.43′	120°45.95′	3.3
2*	34°36.73′	120°46.02′	34°36.76′	121°36.61′	41.6
3	34°46.75′	121°46.05′	34°46.71′	120°41.65′	52.9
4	dropped				
5	35°06.73′	121°43.64′	35°06.71′	120°45.32′	47.7
6	dropped				
7	35°26.72′	121°01.04′	35°26.76′	121°55.78′	44.6
8	35°36.73′	122°04.42′	35°36.75′	121°14.46′	40.6
9	35°46.76′	121°22.21′	35°46.70′	122°13.00′	41.2
10	35°56.72′	121°30.89′	35°56.74′	122°02.37′	25.5
11	36°06.77′	122°11.55′	36°06.71′	121°39.10′	26.2
12	dropped				
13	36°26.76′	122°21.71′	36°26.73′	121°57.19′	19.7
14	36°36.72′	122°06.12′	36°36.74′	121°59.04′	5.7
15	36°46.74′	121°50.46′	36°46.79′	122°19.48′	23.3
16	36°56.71′	122°08.36′	36°56.74′	122°47.51′	31.3
17	37°06.74′	123°06.90′	37°06.72′	122°22.93′	35.1
18	37°16.75′	122°29.03′	37°16.75′	123°14.41′	36.1
19	37°26.75′	123°16.76′	37°26.75′	122°32.00′	35.5
20	37°36.74′	122°43.79′	37°36.75′	123°16.23′	25.7
21*	37°46.76′	122°48.41′	37°46.73′	123°03.59′	12.0
21*	37°48.96′	123°03.60′	37°48.97′	123°15.56′	9.4
21*	37°46.74′	123°15.56′	37°46.61′	123°42.67′	21.4
22	37°56.75′	123°42.51′	37°56.74′	122°53.55′	38.6
23	38°06.74′	122°59.72′	38°06.72′	123°37.54′	29.8
24	38°16.74′	123°40.12′	38°16.74′	123°05.39′	27.3
25	38°26.76′	123°12.48′	38°26.76′	123°47.01′	27.0
26	38°36.72′	123°24.05′	38°36.74′	123°51.32′	21.3
27	38°46.75′	124°04.22′	38°46.73′	123°35.26′	22.6
28	38°56.73′	123°46.25′	38°56.72′	124°06.60′	15.8
29	39°06.64′	124°11.42′	39°06.73′	123°44.90′	20.6
30	dropped				
31	39°26.73′	124°18.32′	39°26.75′	123°51.09′	21.0
32	39°36.76′	123°49.21′	39°36.77′	124°18.02′	22.2
33	39°46.72′	124°19.22′	39°46.75′	123°52.56′	20.5
34	39°56.72′	124°05.52′	39°56.77′	124°54.72′	37.7
35	40°06.74′	124°11.92′	40°06.75′	125°10.19′	44.6
36	40°16.78′	124°23.95′	40°16.75′	125°17.38′	40.8

*Transects 1, 2, 21, and 99 were completed with separate segments of differing latitudes.

Table 3 (continued). Coordinates and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

	Start		End		
Transect	Lat (N)	Long (W)	Lat (N)	Long (W)	Length (nmi)
37	40°26.78′	125°27.28′	40°26.74′	124°31.33′	42.6
38	40°36.73′	124°27.00′	40°36.74′	124°52.55′	19.4
39	40°46.76′	124°18.90′	40°46.73′	125°39.90′	61.3
40	40°56.72′	124°12.98′	40°56.76′	124°55.17′	31.9
41	41°06.73′	124°53.94′	41°06.73′	124°13.25′	30.7
42	41°16.81′	124°10.01′	41°16.73′	124°55.95′	34.5
43	41°26.75′	125°00.03′	41°26.73′	124°10.29′	37.3
44	41°36.74′	124°15.85′	41°36.75′	125°03.21′	35.4
45	41°46.74′	125°04.44′	41°46.71′	124°19.62′	33.4
46	41°56.73′	124°20.20′	41°56.75′	125°07.09′	34.9
47	42°06.80′	124°23.42′	42°06.74′	125°00.48′	27.5
48	42°16.74′	125°01.68′	42°16.74′	124°27.14′	25.6
49	42°26.75′	124°31.43′	42°26.74′	124°53.98′	16.6
50	42°36.77′	125°05.14′	42°36.74′	124°26.94′	28.1
51	42°46.74′	124°39.66′	42°46.81′	125°03.91′	17.8
52	42°56.74′	125°04.16′	42°56.72′	124°32.18′	23.4
53	43°06.76′	124°30.01′	43°06.74′	125°07.05′	27.0
54	43°16.70′	124°27.06′	43°16.76′	125°09.84′	31.1
55	43°26.71′	125°07.81′	43°26.74′	124°19.96′	34.7
56	dropped				
57	43°46.75′	124°13.75′	43°46.74′	125°08.16′	39.3
58	43°56.75′	125°07.62′	43°56.74′	124°12.53′	39.7
59	44°06.74′	125°07.79′	44°06.73′	124°11.73′	40.2
60	44°16.82′	124°11.70′	44°16.74′	125°10.16′	41.9
61	44°26.76′	125°14.85′	44°26.74′	124°10.31′	46.1
62	44°36.74′	124°09.86′	44°36.74′	125°11.33′	43.8
63	44°46.75′	125°17.39′	44°46.76′	124°07.05′	49.9
64	44°56.73′	124°05.01′	44°56.65′	125°15.89′	50.2
65	45°06.72′	125°04.60′	45°06.75′	124°02.71′	43.7
66	dropped				
67	45°26.74′	124°59.19′	45°26.74′	124°01.68′	40.3
68	45°36.71′	125°12.23′	45°36.75′	124°00.73′	50.0
69	45°46.73′	124°01.55′	45°46.76′	125°05.89′	44.9
70	45°56.83′	125°03.96′	45°56.77′	124°02.50′	42.7
71	46°06.70′	124°05.72′	46°06.75′	125°10.40′	44.8
72	46°16.72′	125°02.59′	46°16.73′	124°12.66′	34.5
73	46°26.73′	124°58.05′	46°26.79′	124°14.85′	29.8
74	46°36.80′	124°14.52′	46°36.74′	125°11.23′	39.0
75	46°46.66′	124°17.66′	46°46.75′	125°19.02′	42.0
76	46°56.80′	125°15.58′	46°56.76′	124°21.73′	36.8
88	48°56.73′	127°04.30′	48°56.74′	125°37.53′	57.0
89	49°06.74′	127°10.60′	49°06.75′	126°04.91′	43.0
90	49°16.77′	126°22.89′	49°16.72′	127°27.11′	41.9

Table 3 (continued). Coordinates and length of transects conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

	Start		End		
Transect	Lat (N)	Long (W)	Lat (N)	Long (W)	Length (nmi)
91	49°26.74′	126°42.96′	49°26.76′	127°40.82′	37.6
92	49°36.73′	127°50.04′	49°36.74′	126°56.89′	34.4
93	49°46.77′	127°53.96′	49°46.74′	127°13.62′	26.0
94	49°56.75′	127°22.02′	49°56.73′	128°13.50′	33.1
95	50°06.74′	128°30.95′	50°06.76′	127°58.08′	21.1
96	50°16.71′	128°03.08′	50°16.84′	128°35.00′	20.4
97	50°26.70′	128°40.33′	50°26.75′	128°07.87′	20.7
98	50°36.74′	128°56.95′	50°36.73′	128°21.38′	22.6
99*	50°45.43′	128°29.30′	50°45.42′	128°49.22′	12.6
99*	50°46.78′	128°49.05′	50°46.71′	129°30.18′	26.0
100	50°56.74′	129°47.50′	50°56.74′	128°11.11′	60.7
101	51°14.78′	128°15.63′	51°14.73′	130°17.82′	76.5
102	51°36.75′	128°11.63′	51°36.76′	130°49.27′	97.9

*Transects 1, 2, 21, and 99 were completed with separate segments of differing latitudes.

Table 4. Coordinates and length of transects conducted by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

	Start		End		
Transect	Lat (N)	Long (W)	Lat (N)	Long (W)	Length (nmi)
77	47°06.70′	124°23.96′	47°06.74′	125°08.77′	30.5
78	47°16.67′	124°28.94′	47°16.80′	125°17.25′	32.8
79	47°26.74′	124°33.43′	47°26.92′	125°35.60′	42.0
80	47°36.69′	124°36.73′	47°36.63′	126°05.30′	59.7
81	47°46.73′	125°53.84′	47°46.78′	124°42.50′	47.9
82	47°56.85′	124°48.23′	47°56.75′	125°52.69′	43.2
83	48°06.82′	124°51.72′	48°06.74′	126°09.80′	52.1
84	48°16.73′	126°18.62′	48°16.77′	124°51.15′	58.2
85	48°26.84′	124°42.64′	48°26.83′	126°32.49′	72.9
86	48°36.72′	126°49.08′	48°36.90′	125°21.03′	58.2
87	48°46.74′	125°15.90′	48°46.78′	126°56.99′	66.6
103	51°56.72′	128°31.07′	51°56.79′	131°00.02′	91.8
104	52°16.77′	131°03.11′	52°16.70′	128°46.67′	83.5
105	52°36.72′	129°31.28′	52°36.72′	131°24.05′	68.5
106	52°56.72′	129°40.34′	52°56.69′	130°45.14′	39.0
107	53°17.13′	130°37.88′	53°16.72′	131°06.47′	17.1
108	53°36.72′	130°37.72′	53°36.76′	130°55.88′	10.8
109	53°56.65′	131°04.72′	53°56.76′	130°56.70′	4.7
110	54°16.57′	130°56.42′	54°16.79′	131°25.45′	17.0
111	54°16.79′	131°25.45′	54°47.70′	131°26.30′	30.9
112	54°40.86′	132°00.70′	54°09.62′	131°59.93′	31.2
113	54°08.33′	132°35.50′	54°40.74′	132°35.44′	32.4
114	54°36.74′	132°47.40′	54°36.72′	134°10.87′	48.3
115	54°16.70′	134°13.49′	54°16.72′	133°04.43′	40.3
116	53°56.73′	133°19.71′	53°56.75′	133°58.92′	23.1
117	53°36.84′	133°25.30′	53°36.81′	133°00.70′	14.6
118	53°16.72′	133°22.01′	53°16.74′	132°44.05′	22.7
119	52°56.88′	132°56.69′	52°56.66′	132°26.47′	18.2
120	52°36.79′	132°06.48′	52°36.46′	131°57.25′	5.6
121	52°16.63′	131°47.90′	52°16.66′	131°31.02′	10.3
122	51°56.81′	131°19.30′	51°56.69′	131°03.68′	9.6

Table 5. Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

											Catch		
					Start position		Depth (m)		Temp (°C)		Pacific hake		Other
Trawl	Transect	Date	Time (PDT)	Duration (min)[a]	Lat (N)	Long (W)	Gear[b]	Bottom	Gear[c]	Surface	kg	*n*	kg
1	2	28 Jun	8:33	12.3	34°36.71′	120°50.43′	162	326	9.45	13.24	15.1	2,674	58.7
2	5	29 Jun	10:22	27.9	35°06.61′	121°08.12′	271	554	8.63	14.19	60.4	592	14.6
3[d]	5	29 Jun	14:08	trawl aborted because of marine mammals							—	—	2.0
4	5	29 Jun	18:17	11.5	35°06.14′	120°56.80′	244	256	9.01	14.04	111.8	1,790	7.3
5	7	30 Jun	8:21	27.9	35°26.47′	121°10.33′	280	326	8.59	11.88	230.2	1,196	26.0
6	9	6 Jul	16:24	10.5	35°47.09′	121°30.54′	334	411	8.73	15.02	215.8	2,959	12.6
7	10	7 Jul	9:24	12.3	35°56.47′	121°48.86′	258	1,082	8.10	14.26	0.3	3	14.1
8	11	7 Jul	16:39	trawl aborted because of marine mammals									
9	13	8 Jul	10:11	3.9	36°26.08′	122°01.50′	279	701	8.13	12.42	184.8	1,114	11.8
10	15	8 Jul	16:04	11.3	36°46.44′	121°58.56′	200	678	8.92	13.31	49.8	521	7.1
11	17	9 Jul	14:40	20.4	37°06.81′	122°42.77′	266	336	8.49	13.54	83.3	467	76.7
12	19	10 Jul	12:01	20.9	37°26.67′	122°58.86′	338	399	8.26	12.95	161.0	763	8.5
13	21	11 Jul	15:03	7.5	37°46.49′	123°34.01′	270	2,463	8.42	12.02	253.6	1,846	5.4
14	23	12 Jul	15:07	3.9	38°06.46′	123°22.22′	144	197	9.36	11.74	10.6	3,957	51.3
15	23	12 Jul	18:09	8.6	38°07.12′	123°30.59′	360	508	7.51	11.87	279.7	1,005	2.0
16	24	13 Jul	8:10	10.2	38°16.51′	123°31.38′	287	335	8.01	11.90	305.2	1,342	36.7
17	26	14 Jul	9:16	trawl aborted because of gear issues									
18	26	14 Jul	13:23	15.1	38°36.41′	123°44.13′	430	526	6.69	11.22	85.4	267	1.4
19	26	14 Jul	16:21	11.1	38°36.55′	123°46.07′	351	679	6.85	11.48	39.9	144	6.4
20	29	15 Jul	17:11	15.5	39°05.72′	123°59.16′	369	402	7.35	11.80	432.8	1,624	15.8
21	32	16 Jul	12:12	22.0	39°36.74′	123°58.23′	213	255	8.44	11.36	1.8	49	3.6
22	35	25 Jul	9:03	20.7	40°06.61′	124°21.33′	424	434	6.41	10.68	92.3	282	7.6
23	35	25 Jul	12:26	10.4	40°06.52′	124°21.81′	199	470	8.22	10.56	8.4	27	3.5
24	35	25 Jul	17:30	15.5	40°06.42′	124°49.41′	299	1,034	7.17	13.92	80.6	139	18.5

[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] Trawl 3 was in the water near the surface, before the trawl doors were shot, when a marine mammal abort was called; the net caught pyrosomes.

Table 5 (continued). Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

					Start position		Depth (m)		Temp (°C)		Catch		
											Pacific hake		Other
Trawl	Transect	Date	Time (PDT)	Duration (min)[a]	Lat (N)	Long (W)	Gear[b]	Bottom	Gear[c]	Surface	kg	*n*	kg
25	36	26 Jul	8:39	21.3	40°16.41′	124°37.08′	281	476	7.57	10.27	18.8	56	4.9
26	37	27 Jul	9:41	15.7	40°27.05′	124°37.58′	395	434	7.60	10.29	85.9	267	5.4
27	38	27 Jul	15:05	20.7	40°36.67′	124°31.82′	237	457	8.24	13.03	752.4	2,400	10.5
28	39	28 Jul	8:56	3.2	40°47.18′	124°27.29′	149	170	8.32	12.79	26.7	1,392	55.8
29	39	28 Jul	13:09		trawl aborted because of gear issues								
30	39	28 Jul	14:53	31.3	40°46.41′	124°58.37′	323	>1,500	6.93	14.18	18.6	33	8.0
31	40	29 Jul	10:10	17.0	40°56.38′	124°43.11′	277	732	7.67	14.03	0.3	1	7.7
32	41	29 Jul	17:08	11.5	41°06.69′	124°28.75′	294	738	7.50	13.75	149.6	402	9.0
33	42	30 Jul	8:54	12.1	41°16.11′	124°25.72′	292	299	7.67	12.68	906.1	2,163	16.7
34	46	31 Jul	17:01	25.5	41°55.83′	124°34.94′	317	344	7.55	10.96	101.7	188	6.5
35	47	1 Aug	8:41	12.2	42°06.62′	124°38.17′	319	426	7.06	11.20	359.5	617	5.1
36	47	1 Aug	11:06	17.4	42°06.46′	124°37.38′	369	379	6.91	11.22	442.3	1,023	8.6
37	50	2 Aug	12:44	3.6	42°36.91′	124°42.96′	246	279	7.66	13.47	589.0	1,551	13.3
38	50	2 Aug	14:35	3.7	42°36.68′	124°43.41′	282	322	7.75	13.16	448.9	1,009	5.5
39	52	3 Aug	12:12	20.1	42°56.83′	124°56.22′	480	531	6.54	13.75	228.2	418	68.4
40	54	4 Aug	9:06	7.9	43°15.48′	124°46.62′	397	427	6.56	17.49	179.3	334	6.6
41	55	4 Aug	15:42	21.9	43°26.54′	124°52.08′	340	587	6.58	18.99	17.0	30	13.4
42	57	10 Aug	19:05	12.0	43°46.32′	124°38.09′	315	331	7.41	18.93	1,077.1	2,500	3.8
43	58	11 Aug	11:25	9.3	43°56.65′	124°57.13′	278	355	7.59	19.12	550.5	1,029	51.7
44	58	11 Aug	15:49	7.4	43°57.30′	124°42.07′	—	146	7.71	18.51	open codend		
45	59	12 Aug	8:42	2.9	44°07.00′	124°57.32′	231	246	7.61	15.89	184.3	318	0.0
46	60	12 Aug	19:05	5.5	44°16.35′	124°55.91′	330	367	7.25	16.57	217.0	360	2.1
47	62	13 Aug	19:14	20.1	44°36.39′	124°48.44′	323	335	6.91	18.09	40.9	69	2.7
48	62	14 Aug	8:21	28.0	44°36.51′	124°52.40′	443	463	5.95	18.08	76.4	121	7.7
49	64	15 Aug	8:51	29.5	44°56.69′	124°19.83′	151	169	7.76	12.79	1.2	2	118.5

[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.

Table 5 (continued). Station and catch data summary of midwater trawls conducted by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

											Catch		
			Time	Duration	Start position		Depth (m)		Temp (°C)		Pacific hake		Other
Trawl	Transect	Date	(PDT)	(min)[a]	Lat (N)	Long (W)	Gear[b]	Bottom	Gear[c]	Surface	kg	*n*	kg
50	67	16 Aug	9:53	30.7	45°26.60′	124°26.78′	220	298	7.30	14.32	104.2	156	39.2
51	67	16 Aug	15:51	20.5	45°26.94′	124°27.44′	301	323	6.96	13.99	98.3	142	23.3
52	68	17 Aug	10:27	20.2	45°36.28′	124°34.12′	316	334	7.01	18.27	335.1	485	5.3
53	69	17 Aug	17:44	8.8	45°46.69′	124°18.57′	134	145	7.67	16.69	11.5	16	15.3
54	71	19 Aug	10:55	23.1	46°07.00′	124°42.17′	409	605	6.52	17.03	73.7	109	438.2
55	73	20 Aug	10:17	20.3	46°26.94′	124°33.10′	288	598	7.05	15.69	431.6	632	22.6
56	75	21 Aug	13:21	37.3	46°47.36′	124°52.80′	179	317	7.39	14.61	15.5	23	556.5
57[e]	75	21 Aug	14:14		trawl aborted because of gear issues						—	—	5.0
58	76	22 Aug	10:01	61.3	46°58.35′	125°00.54′	176	641	7.42	16.12	—	—	328.0
59	88	28 Aug	13:53	10.1	48°56.57′	126°33.76′	429	568	6.46	14.48	81.0	102	75.5
60	91	30 Aug	9:54	4.5	49°27.28′	127°04.10′	135	142	7.44	14.40	—	—	70.0
61	91	30 Aug	13:30	20.2	49°26.84′	127°17.57′	458	728	6.13	15.99	52.0	70	49.4
62	93	31 Aug	9:37	15.3	49°46.94′	127°41.06′	350	507	6.54	16.03	3.4	4	151.2
63	96	1 Sep	12:54	12.0	50°17.05′	128°12.53′	201	368	7.44	13.29	1.2	1	1,617.4
64	101	4 Sep	13:59	10.3	51°14.64′	130°02.73′	438	553	5.57	13.46	18.5	16	48.6
65	102	5 Sep	16:36	19.9	51°36.05′	130°05.63′	382	593	6.00	14.75	3.9	3	52.7
66	102	6 Sep	8:48	10.1	51°37.38′	130°27.93′	417	557	5.80	13.83	—	—	23.7
67	102	6 Sep	13:24	20.2	51°36.82′	130°35.24′	405	1,248	5.66	14.10	—	—	18.1

[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.
[e] Trawl 57 was at a depth of 30–40 m for >75 minutes while gear repairs were made; the net never opened properly, yet still caught nonhake species.

Table 6. Station and catch data summary of midwater trawls conducted by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

					Start position		Depth (m)		Temp (°C)		Catch		
											Pacific hake		Other
Trawl	Transect	Date	Time (PDT)	Duration (min)	Lat (N)	Long (W)	Gear[a]	Bottom	Gear[b]	Surface	kg	*n*	kg
1[c]	—	18 Aug	16:21	15	47°41.31′	124°54.95′	71[d]	113	5.71	12.2	—	—	—
2[c]	—	18 Aug	18:42	11	47°30.28′	124°54.78′	88	180	8.82	13.1	—	—	—
3	79	20 Aug	8:39	34	47°26.50′	124°49.77′	261	381	7.47	12.0	233.4	328	53.3
4	80	21 Aug	10:18	30	47°36.03′	125°05.86′	380	399	6.40	12.6	6.7	10	5.4
5	81	22 Aug	9:25	25	47°47.95′	125°04.40′	261	379	7.58	12.1	—	—	289.2
6	82	22 Aug	17:16	30	47°56.88′	125°33.88′	179[d]	216	7.30	12.5	—	—	10,753.9
7	82	23 Aug	9:11	23	48°06.20′	125°04.65′	296	327	7.25	11.5	4.3	3	40.7
8	82	23 Aug	12:38	5	48°06.73′	125°32.01′	128	136	8.22	11.7	—	—	277.3
9	82	23 Aug	14:58	24	48°06.69′	125°41.22′	134[d]	251	7.80	13.1	—	—	205.5
10	84	24 Aug	14:02	30	48°17.84′	125°00.45′	270	271	7.23	11.5	304.6	301	42.3
11	85	25 Aug	11:06	15	48°26.79′	125°56.67′	149	155	7.99	12.5	—	—	4,478.8
12	85	25 Aug	13:43	23	48°26.85′	126°08.15′	256	265	7.11	14.3	162.9	191	103.5
13	85	25 Aug	16:08	62	48°27.04′	126°19.07′	442	1,024	5.93	14.5	—	—	44.5
14	86	26 Aug	9:23	5	48°36.76′	126°07.53′	146	152	8.01	12.3	—	—	20.8
15	86	26 Aug	11:35	15	48°35.53′	126°12.15′	456[d]	585	6.01	11.8	55.0	70	102.1
16	87	27 Aug	8:03	21	48°43.89′	125°46.19′	104	118	8.38	10.9	2.1	1	425.1
17	87	27 Aug	12:21	14	48°46.92′	126°21.59′	224[d]	262	7.25	13.6	27.5	29	1,139.6
18	103	29 Aug	15:54	30	51°56.47′	130°32.09′	358[d]	433	5.72	15.0	—	—	94.5
19	104	30 Aug	11:46	17	52°19.13′	130°14.56′	281[d]	371	5.92	15.3	—	—	14.1
20	104	30 Aug	18:36	12	52°17.88′	128°47.63′	151	192	6.87	14.3	—	—	30.4
21	105	31 Aug	9:11		trawl aborted because of gear issues						—	—	16.3
22	105	31 Aug	14:10	30	52°36.50′	129°57.95′	239	263	6.28	14.3	—	—	59.2
23	106	1 Sep	9:29	20	52°56.76′	130°06.10′	195	239	6.45	11.5	—	—	77.7
24	107	1 Sep	15:51	31	53°17.58′	130°35.99′	139	159	6.91	12.2	—	—	15.1
25	112	3 Sep	9:22	30	54°19.83′	131°58.82′	189	237	6.16	12.1	—	—	78.6
26	112	3 Sep	14:20	6	54°15.05′	131°49.68′	133[d]	175	6.44	12.0	1.2	1	674.5
27	112	3 Sep	16:38	16	54°23.80′	131°31.90′	175	247	5.99	11.6	—	—	75.7
28	114	7 Sep	8:26	21	54°36.68′	134°04.85′	385[d]	644	5.63	13.1	—	—	22.4
29	115	7 Sep	15:30	30	54°16.81′	133°26.52′	300	359	6.06	10.7	—	—	34.3
30	117	8 Sep	15:25	25	53°37.54′	133°21.53′	426	787	5.61	14.4	—	—	5.3

[a] Gear depths were measured at the foot rope.
[b] Gear temperatures were measured at the head rope.
[c] Trawls 1 and 2 were test trawls.
[d] Gear depths for these trawls were measured at the head rope, not the foot rope, because net height had not been recorded.

Table 7. Catch by species from 50 successful and two aborted midwater trawls conducted in U.S. waters by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	**Scientific name**	**Weight (kg)**	**Number**
Pacific hake	*Merluccius productus*	10,243.5	40,607
yellowtail rockfish	*Sebastes flavidus*	889.7	581
Pacific ocean perch	*Sebastes alutus*	374.1	420
pyrosome, unidentified	Pyrosomida	146.3	13,354
sunrise jellyfish	*Chrysaora melanaster*	92.3	81
salp, unidentified	Salpida	86.3	1,709
lanternfish, unidentified	Myctophidae	80.9	15,956
Pacific spiny dogfish	*Squalus suckleyi*	77.8	411
northern anchovy	*Engraulis mordax*	64.6	3,121
Pacific herring	*Clupea pallasi*	62.7	694
brown cat shark	*Apristurus brunneus*	49.9	72
king salmon	*Oncorhynchus tshawytscha*	45.1	37
widow rockfish	*Sebastes entomelas*	42.9	37
blue shark	*Prionace glauca*	35.0	1
king-of-the-salmon	*Trachipterus altivelis*	32.3	14
rougheye/blackspotted rockfish	*Sebastes* sp.	28.7	10
splitnose rockfish	*Sebastes diploproa*	22.5	64
boreal clubhook squid	*Onychoteuthis borealijaponicus*	20.6	169
jack mackerel	*Trachurus symmetricus*	16.5	24
giant grenadier	*Albatrossia pectoralis*	16.3	12
darkblotched rockfish	*Sebastes crameri*	16.2	10
moroteuthid squid, unidentified	*Moroteuthis* sp.	10.3	2
eulachon	*Thaleichthys pacificus*	9.6	448
redstripe rockfish	*Sebastes proriger*	6.5	11
opalescent inshore squid	*Doryteuthis opalescens*	5.5	404
glass shrimp	*Pasiphaea pacifica*	3.3	1,584
chilipepper rockfish	*Sebastes goodei*	3.3	3
sablefish	*Anoplopoma fimbria*	3.1	24
coho salmon	*Oncorhynchus kisutch*	3.1	1
sharpchin rockfish	*Sebastes zacentrus*	1.7	2
California smoothtongue	*Leuroglossus stilbius*	1.4	285
California headlightfish	*Diaphus theta*	1.3	327
shortbelly rockfish	*Sebastes jordani*	1.2	6
jewel squid	*Histioteuthis heteropsis*	1.0	18
Pacific lamprey	*Entosphenus tridentatus*	0.9	5
squid, unidentified	Teuthida	0.5	71
magistrate armhook squid	*Berryteuthis magister*	0.5	3
moon jellyfish, unidentified	*Aurelia* sp.	0.5	1
viperfish, unidentified	Chauliodontidae	0.3	17
glassy nautilus	*Carinaria cristata*	0.2	1
clawed armhook squid	*Gonatus onyx*	0.2	31
jellyfish, unidentified	Scyphozoa	0.2	2
California lanternfish	*Symbolophorus californiensis*	0.2	26

Table 7 (continued). Catch by species from 50 successful and two aborted midwater trawls conducted in U.S. waters by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	Scientific name	Weight (kg)	Number
rex sole	*Glyptocephalus zachirus*	0.1	1
barracudina, unidentified	Paralepididae	0.1	3
medusafish	*Icichthys lockingtoni*	0.1	10
oceanic shrimp	*Sergestes similis*	0.1	47
northern pearleye	*Benthalbella dentata*	0.1	1
Pacific viperfish	*Chauliodus macouni*	0.1	4
flatfish larvae, unidentified	Pleuronectiformes	<0.1	49
Pacific sardine	*Sardinops sagax*	<0.1	1
wolf eel	*Anarrhichthys ocellatus*	<0.1	2
blue lanternfish	*Tarletonbeania crenularis*	<0.1	22
fish larvae, unidentified	Osteichthyes	<0.1	11
skate egg case, unidentified	—	<0.1	2
eelpout, unidentified	Zoarcidae	<0.1	1
hatchetfish, unidentified	Sternoptychidae	<0.1	2
glass squid	*Cranchia scabra*	<0.1	1
shrimp, unidentified	Decapoda	<0.1	4
blacktip poacher	*Xeneretmus latifrons*	<0.1	1
silvery hatchetfish	*Argyropelecus sladeni*	<0.1	1

Table 8. Catch by species from nine midwater trawls conducted in Canadian waters by the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	**Scientific name**	**Weight (kg)**	**Number**
yellowtail rockfish	*Sebastes flavidus*	1,197.2	826
widow rockfish	*Sebastes entomelas*	264.8	169
Pacific hake	*Merluccius productus*	159.9	196
redstripe rockfish	*Sebastes proriger*	129.9	180
rougheye/blackspotted rockfish	*Sebastes* sp.	129.1	129
silvergray rockfish	*Sebastes brevispinis*	110.1	51
Pacific ocean perch	*Sebastes alutus*	65.9	54
Pacific herring	*Clupea pallasi*	61.1	671
lanternfish, unidentified	Myctophidae	39.7	6,455
brown cat shark	*Apristurus brunneus*	28.5	69
bocaccio	*Sebastes paucispinis*	23.9	10
lion’s mane jellyfish	*Cyanea capillata*	20.2	8
egg-yolk jellyfish	*Phacellophora camtschatica*	12.7	10
canary rockfish	*Sebastes pinniger*	9.1	4
salp, unidentified	Salpida	4.0	236
yellowmouth rockfish	*Sebastes reedi*	2.1	2
sergestid shrimp, unidentified	Sergestidae	1.7	908
glass shrimp	*Pasiphaea pacifica*	1.6	1,035
clawed armhook squid	*Gonatus onyx*	1.5	164
moroteuthid squid	*Moroteuthis* sp.	0.9	1
darkblotched rockfish	*Sebastes crameri*	0.7	1
squid, unidentified	Teuthida	0.7	29
boreal clubhook squid	*Onychoteuthis borealijaponicus*	0.3	6
octopus squid	*Octopoteuthis deletron*	0.3	1
jellyfish, unidentified	Scyphozoa	0.3	27
Pacific viperfish	*Chauliodus macouni*	0.1	8
viperfish, unidentified	Chauliodontidae	0.1	7
fish, unidentified	Osteichthyes	0.1	2
eulachon	*Thaleichthys pacificus*	<0.1	2
barracudina, unidentified	Paralepididae	<0.1	1
sunbeam lightfish	*Lampadena urophaos*	<0.1	1
rex sole larvae	*Glyptocephalus zachirus*	<0.1	3
medusafish	*Icichthys lockingtoni*	<0.1	1
bluethroat argentine	*Nansenia candida*	<0.1	1
longfin dragonfish	*Tactostoma macropus*	<0.1	3
flatfish larvae, unidentified	Pleuronectiformes	<0.1	10
deepwater eelpout	*Lycodapus endemoscotus*	<0.1	1
chiroteuthid squid	*Chiroteuthis calyx*	<0.1	1

Table 9. Catch by species from eight midwater trawls conducted in U.S. waters by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	Scientific name	Weight (kg)	Number
yellowtail rockfish	*Sebastes flavidus*	5,403.7	3,014
widow rockfish	*Sebastes entomelas*	5,309.9	5,019
Pacific hake	*Merluccius productus*	549.0	642
Pacific herring	*Clupea pallasi*	495.9	4,362
Pacific krill	*Euphausia pacifica*	112.0	—
splitnose rockfish	*Sebastes diploproa*	106.8	114
glass shrimp	*Pasiphaea pacifica*	>38.7	—
redstripe rockfish	*Sebastes proriger*	33.0	20
Pacific ocean perch	*Sebastes alutus*	29.1	24
big skate	*Raja binoculata*	25.7	2
California headlightfish	*Diaphus theta*	18.7	—
spotted ratfish	*Hydrolagus colliei*	11.5	14
jack mackerel	*Trachurus symmetricus*	10.7	14
lion's mane jellyfish	*Cyanea capillata*	9.5	—
sablefish	*Anoplopoma fimbria*	8.8	15
darkblotched rockfish	*Sebastes crameri*	8.5	15
egg-yolk jellyfish	*Phacellophora camtschatica*	7.0	—
Pacific spiny dogfish	*Squalus suckleyi*	5.4	15
eulachon	*Thaleichthys pacificus*	5.4	144
arrowtooth flounder	*Atheresthes stomias*	4.6	3
bocaccio	*Sebastes paucispinis*	4.1	1
lanternfish, unidentified	Myctophidae	4.1	—
canary rockfish	*Sebastes pinniger*	2.6	1
pink salmon	*Oncorhynchus gorbuscha*	2.4	1
crystal jellyfish	*Aequorea victoria*	1.2	—
Pacific lamprey	*Entosphenus tridentatus*	1.0	24
squid, unidentified	Teuthida	1.0	>6
shortbelly rockfish	*Sebastes jordani*	0.8	>1
American shad	*Alosa sapidissima*	0.8	1
walleye pollock	*Gadus chalcogrammus*	0.7	1
salp, unidentified	Thaliacea	0.7	—
English sole	*Parophrys vetulus*	0.6	1
rougheye rockfish	*Sebastes aleutianus*	0.5	—
opalescent inshore squid	*Doryteuthis opalescens*	0.5	—
ocean shrimp	*Pandalus jordani*	0.5	—
moon jellyfish	*Aurelia aurita*	0.4	—
pallid eelpout	*Lycodapus mandibularis*	0.4	—
oceanic shrimp	*Sergestes similis*	0.1	—
North Pacific frostfish	*Benthodesmus pacificus*	<0.1	1
blue lanternfish	*Tarletonbeania crenularis*	<0.1	—
ribbon barracudina	*Arctozenus risso*	<0.1	3
flatfish, unidentified	Pleuronectiformes	<0.1	—
slender barracudina	*Lestidiops ringens*	<0.1	5

Table 9 (continued). Catch by species from eight midwater trawls conducted in U.S. waters by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	**Scientific name**	**Weight (kg)**	**Number**
Pacific viperfish	*Chauliodus macouni*	<0.1	17
siphonophore, unidentified	Siphonophorae	<0.1	—
snailfish, unidentified	Liparidae	<0.1	—
northern flashlightfish	*Protomyctophum thompsoni*	<0.1	7
jellyfish, unidentified	Scyphozoa	<0.1	—
northern anchovy	*Engraulis mordax*	<0.1	2
rockfish, unidentified	*Sebastes* sp.	<0.1	—
sea cockroach, unidentified	Isopoda	<0.1	—
squat lobster, unidentified	*Munida* sp.	<0.1	—

Table 10. Catch by species from 19 successful and one aborted midwater trawls conducted in Canadian waters by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	**Scientific name**	**Weight (kg)**	**Number**
yellowtail rockfish	*Sebastes flavidus*	4,212.4	3,070
walleye pollock	*Gadus chalcogrammus*	1,237.3	2,240
splitnose rockfish	*Sebastes diploproa*	1,118.5	1,746
Pacific hake	*Merluccius productus*	248.7	292
jack mackerel	*Trachurus symmetricus*	110.5	130
deep sea red shrimp, unidentified	Euphausiacea	107.9	—
canary rockfish	*Sebastes pinniger*	100.0	57
Pacific ocean perch	*Sebastes alutus*	83.6	>89
Pacific herring	*Clupea pallasii*	80.4	1,480
egg-yolk jellyfish	*Phacellophora camtschatica*	49.0	—
rougheye rockfish	*Sebastes aleutianus*	48.5	25
widow rockfish	*Sebastes entomelas*	37.7	>35
king salmon	*Oncorhynchus tshawytscha*	32.7	11
lion’s mane jellyfish	*Cyanea capillata*	31.4	—
jellyfish, unidentified	Scyphozoa	30.6	—
silvergray rockfish	*Sebastes brevispinis*	28.3	14
glass shrimp	*Pasiphaea pacifica*	26.3	—
ragfish	*Icosteus aenigmaticus*	24.2	1
redstripe rockfish	*Sebastes proriger*	20.0	>38
brown cat shark	*Apristurus brunneus*	15.9	31
northern lampfish	*Stenobrachius leucopsarus*	15.4	—
pallid eelpout	*Lycodapus mandibularis*	13.9	—
California headlightfish	*Diaphus theta*	13.5	—
lanternfish, unidentified	Myctophidae	13.3	—
opalescent inshore squid	*Doryteuthis opalescens*	9.0	—
squid, unidentified	Teuthida	7.4	—
longfin dragonfish	*Tactostoma macropus*	4.8	—
sunrise jellyfish	*Chrysaora melanaster*	4.2	>3
eulachon	*Thaleichthys pacificus*	3.8	>482
lingcod	*Ophiodon elongatus*	3.2	2
arrowtooth flounder	*Atheresthes stomias*	2.8	2
deepsea smelt, unidentified	Bathylagidae	2.5	—
long-armed jewel squid	*Histioteuthis hoylei*	2.3	—
squat lobster, unidentified	*Munida* sp.	2.2	—
salp, unidentified	Thaliacea	1.9	—
viperfish, unidentified	Chauliodontinae	1.8	—
oceanic shrimp	*Sergestes similis*	1.7	—
darkblotched rockfish	*Sebastes crameri*	1.7	3
vampire squid, unidentified	*Vampyroteuthis* sp.	1.3	—
blue lanternfish	*Tarletonbeania crenularis*	1.3	—
gonate squid, unidentified	Gonatidae	1.3	—
Pacific pomfret	*Brama japonica*	1.1	1

Table 10 (continued). Catch by species from 19 successful and one aborted midwater trawls conducted in Canadian waters by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	**Scientific name**	**Weight (kg)**	**Number**
Pacific viperfish	*Chauliodus macouni*	0.9	—
moon jellyfish	*Aurelia aurita*	0.9	—
American shad	*Alosa sapidissima*	0.7	4
prowfish	*Zaprora silenus*	0.6	4
Pacific krill	*Euphausia pacifica*	0.5	—
magistrate armhook squid	*Berryteuthis magister*	0.5	—
squid, unidentified	Myopsina	0.5	—
northern pearleye	*Benthalbella dentata*	0.3	—
California lanternfish	*Symbolophorus californiensis*	0.2	—
lanternfish, unidentified	*Tarletonbeania* sp.	0.2	—
octopus squid	*Octopoteuthis deletron*	0.2	2
Pacific lamprey	*Entosphenus tridentatus*	0.2	>2
jewel squid	*Histioteuthis heteropsis*	0.1	1
purple cone jellyfish	*Periphylla periphylla*	0.1	—
salmon or trout, unidentified	Salmonidae	0.1	2
glass squid	*Belonella borealis*	0.1	—
glass squid, unidentified	Taoniinae	0.1	—
siphonophore, unidentified	Siphonophorae	<0.1	—
shrimp, unidentified	Dendrobranchiata	<0.1	—
cusk eel, unidentified	Ophidiidae	<0.1	—
Pacific blacksmelt	*Bathylagus pacificus*	<0.1	—
ribbon barracudina	*Arctozenus risso*	<0.1	—
shining tubeshoulder	*Sagamichthys abei*	<0.1	1
wheel jellyfish, unidentified	*Atolla* sp.	<0.1	—
barreleye	*Macropinna microstoma*	<0.1	2
chiroteuthid squid	*Chiroteuthis calyx*	<0.1	—
slender barracudina	*Lestidiops ringens*	<0.1	—
taillight lanternfish	*Tarletonbeania taylori*	<0.1	—
amphipod, unidentified	Amphipoda	—	—
Dover sole	*Microstomus pacificus*	—	—
fish, unidentified	Osteichthyes	—	1
flatfish, unidentified	Pleuronectiformes	—	1
hatchetfish, unidentified	Sternoptychidae	—	1
Japanese spinyridge	*Notostomus japonicus*	—	2
krill, unidentified	Euphausiidae	—	—
northern flashlightfish	*Protomyctophum thompsoni*	—	>6
northern smoothtongue	*Leuroglossus schmidti*	—	2
octopus, unidentified	Octopodidae	—	>2
Pacific cod	*Gadus macrocephalus*	—	5
Pacific sand lance	*Ammodytes hexapterus*	—	1
Pacific tomcod	*Microgadus proximus*	—	3
pinpoint lampfish	*Nannobrachium regale*	—	—

Table 10 (continued). Catch by species from 19 successful and one aborted midwater trawls conducted in Canadian waters by the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Common name	Scientific name	Weight (kg)	Number
quillfish	*Ptilichthys goodei*	—	2
rex sole	*Glyptocephalus zachirus*	—	—
righteye flounder, unidentified	Pleuronectidae	—	>2
rockfish, unidentified	*Sebastes* sp.	—	—
snailfish, unidentified	Liparidae	—	>1
whitebait smelt	*Allosmerus elongatus*	—	>21

Table 11. Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Trawl	Length	Weight and maturity	Otoliths	Stomachs: Collected	Stomachs: Examined	Gonad collection	Chemical tracer hake
1	565	—	—	—	—	—	15
2	527	51	51	5	5	4	15
3	trawl aborted						
4	487	79	79	5	4	3	15
5	358	51	51	5	5	3	—
6	541	59	59	5	5	3	15
7	3	3	3	2	—	—	—
8	trawl aborted						
9	466	81	81	5	5	3	—
10	414	50	50	5	5	—	—
11	366	51	51	5	5	4	—
12	373	38	38	5	5	3	—
13	499	67	67	5	5	—	15
14	112	—	—	—	—	—	—
15	331	50	50	5	5	2	15
16	391	51	51	5	5	2	—
17	trawl aborted						
18	267	69	69	5	5	4	—
19	144	48	48	5	5	—	—
20	409	44	44	5	5	—	—
21	49	6	6	5	1	—	—
22	282	68	68	5	5	6	15
23	27	27	27	5	5	6	—
24	139	46	46	5	5	1	—
25	56	48	48	5	5	2	8
26	267	43	43	5	5	—	7
27	385	43	43	5	5	—	—
28	116	53	53	5	5	1	—
29	trawl aborted						
30	33	33	33	5	5	1	—
31	1	1	1	1	—	—	—
32	402	42	42	5	5	—	—
33	374	56	56	5	5	1	—
34	188	36	36	5	5	1	—
35	281	38	38	5	5	—	—
36	390	55	55	5	5	—	—
37	378	60	60	5	5	—	15
38	376	50	50	5	5	—	—
39	393	49	49	5	5	—	—
40	334	47	47	5	5	—	—
41	30	29	29	6	5	—	—
42	416	59	59	5	5	6	—

Table 11 (continued). Numbers of Pacific hake biological samples and measurements collected on the NOAA Ship *Bell M. Shimada* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

				Stomachs			
Trawl	**Length**	**Weight and maturity**	**Otoliths**	**Collected**	**Examined**	**Gonad collection**	**Chemical tracer hake**
43	374	42	42	5	5	4	—
44	open-codend trawl						
45	318	50	50	5	5	2	—
46	360	49	49	5	5	1	—
47	69	50	50	5	5	3	—
48	121	50	50	5	5	2	—
49	2	2	2	1	—	—	—
50	156	42	42	5	5	1	—
51	142	51	51	5	5	—	—
52	328	45	45	5	5	—	—
53	16	16	16	5	5	—	—
54	109	46	46	5	5	—	—
55	331	39	39	5	5	—	—
56	23	23	23	5	5	—	—
57	trawl aborted						
58	—	—	—	—	—	—	—
59	40	40	40	5	2	3	—
60	—	—	—	—	—	—	—
61	70	47	47	5	5	4	—
62	4	4	4	3	—	1	—
63	1	1	1	1	—	1	—
64	16	16	16	3	4	1	—
65	3	3	3	—	—	—	—
66	—	—	—	—	—	—	—
67	—	—	—	—	—	—	—
Totals	**12,884**	**2,198**	**2,198**	**242**	**226**	**79**	**135**

Table 12. Numbers of Pacific hake biological samples and measurements collected on the Canadian Coast Guard Ship *Sir John Franklin* during the 2023 Joint U.S.–Canada Integrated Ecosystem and Pacific Hake Acoustic Trawl Survey.

Trawl	Length	Weight and maturity	Otoliths	Stomachs examined
1	—	—	—	—
2	—	—	—	—
3	344	50	50	20
4	10	10	10	10
5	—	—	—	—
6	—	—	—	—
7	3	3	3	1
8	—	—	—	—
9	—	—	—	—
10	295	50	50	19
11	—	—	—	—
12	187	49	49	16
13	—	—	—	—
14	—	—	—	—
15	69	69	69	12
16	1	1	1	1
17	29	29	29	19
18	—	—	—	—
19	—	—	—	—
20	—	—	—	—
21	—	—	—	—
22	—	—	—	—
23	—	—	—	—
24	—	—	—	—
25	—	—	—	—
26	1	1	1	—
27	—	—	—	—
28	—	—	—	—
29	—	—	—	—
30	—	—	—	—
Totals	**939**	**262**	**262**	**98**

U.S. Secretary of Commerce
Gina M. Raimondo

Under Secretary of Commerce for
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