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REPORT ON THE SUMMER 2023 CALIFORNIA CURRENT ECOSYSTEM SURVEY (CCES) (2307RL), 17 JULY TO 3 NOVEMBER 2023, CONDUCTED ABOARD NOAA SHIPS *REUBEN LASKER* AND *BELL M. SHIMADA*, FISHING VESSELS *LISA MARIE* AND *LONG BEACH CARNAGE*, AND THREE UNCREWED SURFACE VESSELS

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Report on the Summer 2023 California Current Ecosystem Survey (CCES) (2307RL), 17 July to 3 November 2023, conducted aboard NOAA Ships *Reuben Lasker* and *Bell M. Shimada*, fishing vessels *Lisa Marie* and *Long Beach Carnage*, and three uncrewed surface vehicles

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1 Introduction

The Summer 2023 California Current Ecosystem Survey (CCES) (2307RL) was conducted by the Fisheries Resources Division (FRD) of the Southwest Fisheries Science Center (SWFSC) aboard NOAA Ships *Reuben Lasker* (hereafter *Lasker*) and *Bell M. Shimada* (hereafter *Shimada*), 17 July to 3 November 2023, and augmented by data collected from the fishing vessels *Lisa Marie* and *Long Beach Carnage* (**Fig.** 1). Uncrewed surface vehicles (USVs; Saildrone, Inc.) also collected acoustic data but were not used for biomass calculations. The Acoustic-Trawl Method (ATM) is routinely used to assess coastal pelagic fish species (CPS) within the California Current Ecosystem (CCE), typically between Vancouver Island, British Columbia and San Diego, CA. Starting in 2021, and as resources have allowed, the survey has extended southward to include central Baja California, Mexico. Data were collected using multi-frequency echosounders, surface trawls, purse seines, obliquely integrating net tows, a Continuous Underway Fish-Egg Sampler (CUFES, Checkley *et al.*, 1997), and conductivity-temperature-depth probes (CTDs).

The objectives for the survey were to:

1. Acoustically map the distributions, measure the species compositions and size-frequency distributions, and estimate the abundances and biomasses of CPS present in the survey area, e.g., Pacific Sardine *Sardinops sagax*, Northern Anchovy *Engraulis mordax*, Pacific Herring *Clupea pallasii*, Round Herring *Etrumeus acuminatus*, Pacific Mackerel *Scomber japonicus*, and Jack Mackerel *Trachurus symmetricus*;
2. Characterize and investigate linkages to their biotic and abiotic environments;
3. Gather information regarding their life histories;
4. Compare the species composition and size distributions of CPS and Pacific Hake *Merluccius productus* between night-time *Lisa Marie* purse seine sets with proximate trawl sampling from *Lasker*, *Shimada*, and Canadian R/V *Franklin*; and
5. Compare the species composition and size distributions of proximate day-time and night-time *Lisa Marie* purse seine sets.

The originally planned survey domain, from Punta Eugenia, Baja CA to Cape Scott, BC, was defined primarily by the historically observed distribution of the northern subpopulation (stock) of Pacific Sardine (Zwolinski *et al.*, 2011), with a southern extension permitted by available sampling effort. This area was chosen to encompass the anticipated distribution of the northern stock of Pacific Sardine and the central and northern stocks of Northern Anchovy off the west coasts of the U.S., Canada, and Mexico, but also spanning portions of the distributions of Pacific Mackerel, Jack Mackerel, Round Herring, Pacific Herring, and the southern stock of Pacific Sardine.

This report provides an overview of the survey objectives and a summary of the survey equipment, sampling protocols, and data collections. This report does not include estimates of the animal distributions and biomasses, which are documented separately (Stierhoff *et al.*, 2024).

Figure 1: NOAA Ship *Lasker* (top), F/V *Lisa Marie* (bottom left), F/V *Long Beach Carnage* (bottom middle), and an uncrewed surface vehicle (Saildrone USV, bottom right). NOAA Ship *Shimada* not pictured.

1.1 Scientific Personnel

The collection and analysis of the survey data were conducted by members of 1-NOAA, 2-UCSC/CIMEAS, 3-OAI, 4-INFISH intern, 5-UCSD/SIO, 6-volunteer, 7-OSU, 8-IMIPAS, 9-WDFW, and 10-CWPA. For each leg, [*] denotes the Cruise Leader, and [+] the Acoustic, Trawl, and CUFES Leads.

The survey on *Lasker* was originally divided into three legs, with each leg consisting of two parts (denoted 1 or 2) and a personnel transfer conducted partway through the leg. Leg I.1 and all of Leg II were canceled due to OMAO staffing shortages and mechanical issues aboard *Lasker*. To mitigate the loss of sea days on *Lasker*, a fourth leg consisting of two parts was added and conducted aboard *Shimada*.

Chief Scientist:

- K. Stierhoff[1]

Acoustic Data Collection and Processing:

- Leg I.2: S. Mau[1+] and D. Palance[2]
- Leg III.1: A. Beittel[1] and D. Murfin[1+]
- Leg III.2: K. Stierhoff[1*+]
- Leg IV.1: A. Beittel[1] and S. Sessions[1*+]
- Leg IV.2: S. Mau[1] and J. Zwolinski[2*+]

Trawl Sampling:

- Leg I.2: B. Bellerud[1], N. Concha-Saiz[1], K. James[1*+], D. Kuyper[3], and S. Mitchell[4]
- Leg III.1: G. Angle[1], S. Callahan[5], D. Kuyper[3], and O. Snodgrass[1*+]
- Leg III.2: J. Evanilla[6], D. Kuyper[3], G. Longo[6], M. Macaskill[5], and O. Snodgrass[1+]
- Leg IV.1: O. Boisen[7], N. Concha-Saiz[1], D. Kuyper[3+], B. Lind[1], and Z. Skelton[3]
- Leg IV.2: M. Dunlap[1], K. James[1+], E. Ruhl[1], and Z. Skelton[3]

CUFES Sampling:

- Leg I.2: S. Morales[8] and L. Vasquez[1+]
- Leg III.1: E. Gardner[1+] and A. Hays[1]
- Leg III.2: N. Concha-Saiz[1] and A. Hays[1+]
- Leg IV.1: CUFES sampling not conducted
- Leg IV.2: CUFES sampling not conducted

Purse-seine Sampling:

- *Lisa Marie*
  - Z. Calef[9] and K. Hinton[9]
- *Long Beach Carnage*
  - J. van Noord[10]

Echosounder Calibrations:

- *Lasker*
  - A. Beittel[1], D. Murfin[1], J. Renfree[1], and S. Sessions[1]

- *Lisa Marie*
  - D. Demer[1] and J. Renfree[1]
- *Long Beach Carnage*
  - J. Renfree[1] and S. Sessions[1]
- *Saildrone*
  - Saildrone, Inc. and J. Renfree[1]

2 Methods

2.1 Survey region and design

The SWFSC's ATM surveys of CPS in the CCE began in 2006 with a focus on the northern stock of Pacific Sardine. Since then, they have expanded in scope and objectives to include the larger forage-fish assemblage and krill. This evolution, and the migratory behavior of Pacific Sardine, serve to explain the present survey region and design.

During summer 2023, the west coasts of the U.S. and Baja California, Mexico were to be surveyed using *Lasker*, *Lisa Marie*, *Long Beach Carnage*, and USVs. Compulsory transects were nearly perpendicular to the coast and separated by 10 nmi. The survey was to begin off Punta Eugenia, Baja CA and progress northwards toward Cape Scott, BC.

The planned core-region transects (**Fig. 3**) spanned the latitudinal extent, based on historical observations, of the anticipated distributions of the northern and southern stocks of Pacific Sardine and the central and northern stocks of Northern Anchovy. For *Lasker*, the planned transects ranged from Punta Eugenia, Baja CA to Cape Scott, BC, spaced 20 nmi apart south of Cape Mendocino, CA, 10 nmi between Cape Mendocino, CA to Cape Flattery, WA, and 20 nmi north of Cape Flattery, WA. Off Vancouver Island, BC, adaptive transects would be added 10 nmi north and south of compulsory transects containing observations of CPS. To further increase the spatial sampling resolution from *Lasker*, USVs were to conduct acoustic sampling interstitial to *Lasker* transects between Point Conception, CA and Cape Mendocino, CA. The USVs were to also sample transects spaced 20 nmi apart north of Cape Mendocino, CA, resulting in *Lasker* and the USVs duplicating every other transect. Lastly, in Baja California the Mexican research vessel *Dr. Jorge Carranza Fraser* was to sample interstitial to *Lasker* transects. The final result would be acoustically-sampled transects spaced 10 nmi apart throughout the entire survey region, except in the Southern California Bight where only *Lasker* would sample with 20-nmi spacing.

To estimate the nearshore CPS biomass in coastal regions where it is too shallow to safely navigate NOAA ships, sampling from *Lasker* was to be augmented with nearshore-region transects using echosounder and purse-seine sampling from *Long Beach Carnage* between San Diego, CA to Bodega Bay, CA, and around Santa Cruz and Santa Catalina Islands; and from *Lisa Marie* between Bodega Bay, CA to Cape Flattery, WA (**Fig. 3**).

To compare the species and size compositions between the various platforms and net systems, *Lisa Marie* was to conduct nighttime purse seine sets in proximity to *Lasker* nighttime surface trawls and *Shimada* daytime midwater trawls (conducted as part of the NWFSC's Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey) between Point Conception, CA to Cape Flattery, WA. *Lisa Marie* would also conduct daytime purse seine sets throughout the nearshore survey to compare with their nighttime catches.

Due to OMAO staffing shortages and mechanical issues on *Lasker*, Leg I.1 and all of Leg II were canceled, prompting modifications to the sampling plan throughout the survey. All transects off Baja California were canceled, with Leg I.2 beginning the survey off San Diego, CA. Because of the delay, *Lasker* was unable to conduct comparative trawls with *Shimada* or *Lisa Marie*. Moreover, because *Lisa Marie* delayed its schedule to synchronize its nearshore sampling with *Lasker*, comparative purse seine catches with *Shimada* were conducted approximately one month apart and only between Point Conception, CA and Point Arena, CA. *Lasker* completed its survey after Leg III, having only sampled to Cape Mendocino, CA. An additional 19 days-at-sea aboard *Shimada* were used to add a Leg IV and sample transects from Cape Mendocino, CA to Cape Flattery, WA. However, due to weather-induced time constraints, *Shimada* only sampled as far south as Reedsport, OR. No changes were made to the sampling plan for *Long Beach Carnage* or the USVs.

For *Lasker* and *Shimada*, the offshore extent of the transects was extended by 5-nmi segments if CPS backscatter, Pacific Sardine or Northern Anchovy eggs, or both were observed during the last 3 nmi of the transect or additional segment, for up to a total extension of 50 nmi. If a transect was extended, the ensuing transect was extended by the same amount.

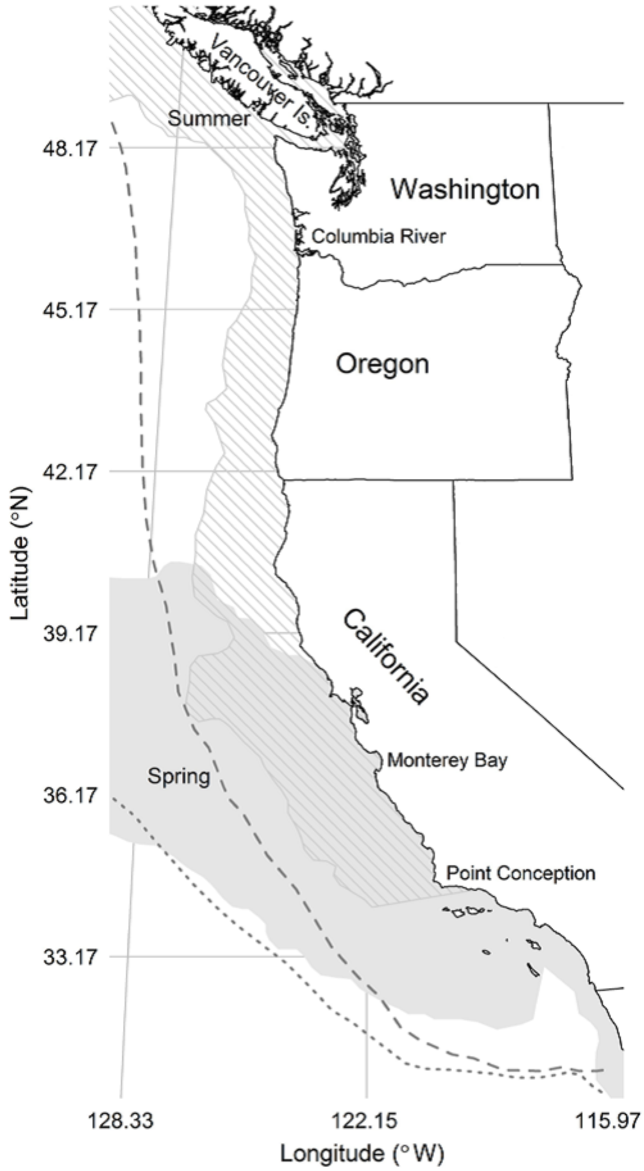

Figure 2: Conceptual spring (shaded region) and summer (hashed region) distributions of potential habitat for the northern stock of Pacific Sardine along the west coasts of Mexico, the United States, and Canada. The dashed and dotted lines represent, respectively, the approximate summer and spring positions of the 0.2 mg m^{-3} chlorophyll-a concentration isoline. This isoline appears to oscillate in synchrony with the transition zone chlorophyll front (TZCF, Polovina *et al.*, 2001) and the offshore limit of the northern stock Pacific Sardine potential habitat (Zwolinski *et al.*, 2011). Mackerels are found within and on the edge of the same oceanographic habitat (e.g., Demer *et al.*, 2012; Zwolinski *et al.*, 2012). The TZCF may delineate the offshore and southern limit of both Pacific Sardine and Pacific Mackerel distributions, and juveniles may have nursery areas in the Southern California Bight, downstream of upwelling regions.

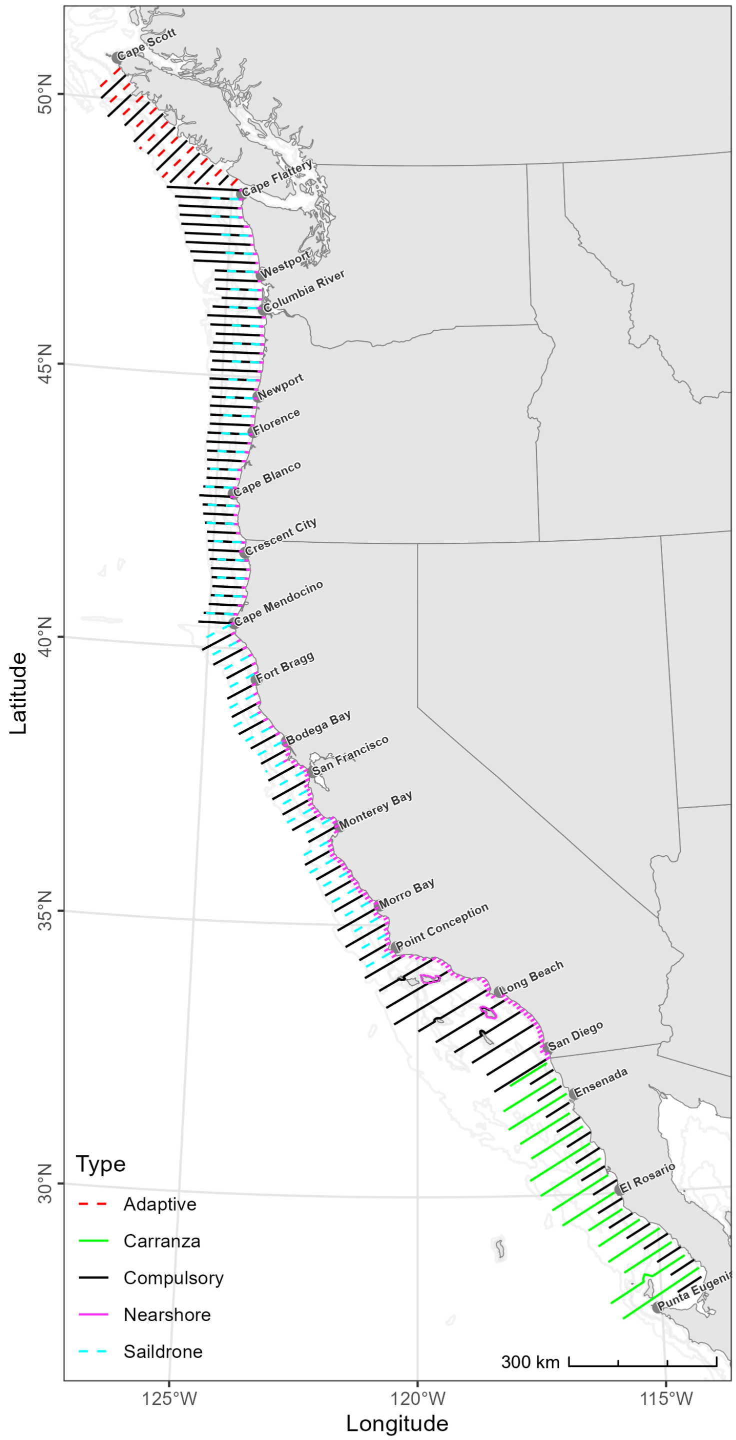

Figure 3: Planned core-region (solid black lines) and adaptive (dashed red lines) transects to be sampled by *Lasker*; core-region transects to be sampled in Baja California, MX by *Carranza* (solid green lines); interstitial transects to be sampled by USVs (dashed cyan lines); and nearshore transect lines to be sampled by fishing vessels (solid magenta lines). Isobaths (light gray lines) are at 50, 200, 500, and 2,000 m (or approximately 25, 100, 250, and 1,000 ftm).

2.2 Acoustic sampling

2.2.1 Echosounders

On *Lasker* and *Shimada*, multi-frequency Wideband Transceivers (Simrad EK80 WBTs; Kongsberg) were configured with split-beam transducers (Simrad ES18, ES38-7, ES70-7C, ES120-7C, ES200-7C, and ES333-7C on *Lasker* and ES18, ES38B, ES70-7C, ES120-7C, and ES200-7C on *Shimada*; Kongsberg). The transducers were mounted on the bottom of a retractable keel or "centerboard" (**Fig. 4**). The keel was retracted (transducers ~5-m depth) during calibration, and extended to the intermediate position (transducers ~7-m depth) during the survey. Exceptions were made during shallow water operations, when the keel was retracted; or during times of heavy weather, when the keel was extended (transducers ~9-m depth) to provide extra stability and reduce the effect of weather-generated noise (**Appendix A**). Transducer position and motion were measured at 5 Hz using an inertial motion unit (Applanix POS-MV; Trimble).

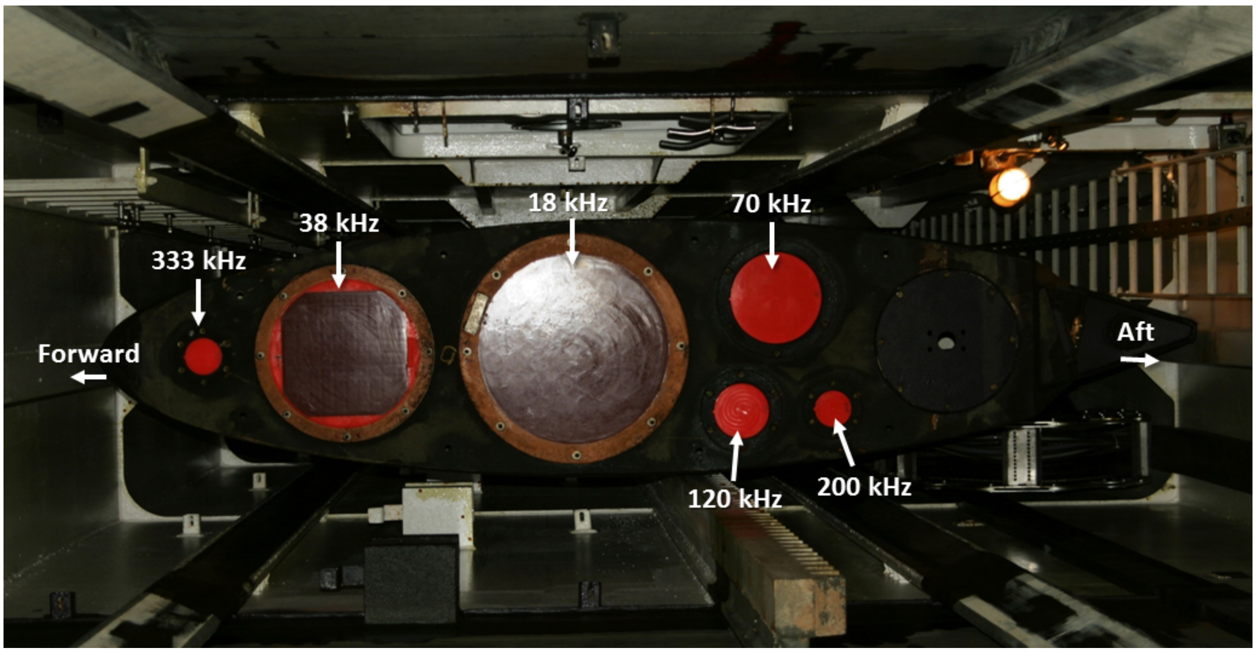

Figure 4: Transducer locations on the bottom of the centerboard aboard *Lasker*.

On *Lisa Marie*, multi-frequency Wideband Transceivers (Simrad EK80 WBTs; Kongsberg) were connected to the vessel's hull-mounted split-beam transducers (Simrad ES38-7, ES70-7C, ES120-7C, and ES200-7C; Kongsberg; **Fig. 5**).

Figure 5: Transducer locations mounted on the hull of *Lisa Marie*.

On *Long Beach Carnage*, the SWFSC's multi-frequency General Purpose Transceivers (Simrad EK60 GPTs; Kongsberg) were configured with the SWFSC's split-beam transducers (Simrad ES38-12, ES70-7C, ES120-7C and ES200-7C; Kongsberg) mounted in a multi-frequency transducer array (MTA4) on the bottom of a pole (**Fig. 6**).

Figure 6: Transducer locations on the bottom of the pole-mounted multi-transducer array (MTA4) installed on the F/V *Long Beach Carnage*.

On the three USVs (SD-1048, SD-1060, and SD-1096), miniature Wideband Transceivers (Simrad WBT-Mini; Kongsberg) were configured with gimbaled, keel-mounted, dual-frequency transducers (Simrad ES38-18|200-18C; Kongsberg) containing a split-beam 38-kHz transducer and single-beam 200-kHz transducer with nominally 18° beamwidths.

2.2.2 Calibrations

The echosounder systems on each vessel were calibrated using the standard sphere technique (Demer *et al.*, 2015; Foote *et al.*, 1987). On *Lasker*, each WBT was calibrated in both CW (continuous wave or narrowband mode) and FM modes (frequency modulation or broadband mode). For both modes, the reference target was a 38.1-mm diameter sphere made from tungsten carbide (WC) with 6% cobalt binder material (WC38.1). For FM mode, additional calibrations were conducted for the 120, 200, and 333-kHz echosounders using a smaller 25-mm WC sphere. Calibrations for *Shimada*, *Lisa Marie*, *Long Beach Carnage*, and the USVs were all conducted using a WC38.1. The *Shimada* calibration was conducted by the Northwest Fisheries Science Center after completion of the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey. The calibration parameters for all vessels were derived in Echoview (see **Section 3.1**). For each echosounder, the calibrated Equivalent Two-Way Beam Angle (EBA) was derived by compensating the factory-measured EBA by the change in local sound speed (Bodholt, 2002; Demer *et al.*, 2015); when processing the survey transects, the calibrated measures of transducer gain, beamwidths, and EBA were then also compensated by the changes in local sound speed.

2.2.3 Data collection

On *Lasker* and *Shimada*, the computer clocks were synchronized with the GPS clock (UTC) using synchronization software (NetTime[1]). The 18-kHz WBT, operated by a separate PC from the other echosounders, was programmed to track the seabed and output the detected depth to the ship's Scientific Computing System (SCS). The 38-, 70-, 120-, 200-, and 333-kHz echosounders were controlled by the EK80 Adaptive Logger (EAL[2], Renfree and Demer, 2016). The EAL optimizes the pulse interval based on the seabed depth, while avoiding aliased seabed echoes, and was programmed such that once an hour the echosounders would record three pings in passive mode, for obtaining estimates of the background noise level. Acoustic sampling for CPS-density estimation along the pre-determined transects was limited to daylight hours (approximately between sunrise and sunset).

Measurements of volume backscattering strength (S_v; dB re 1 m^2 m^{-3}) and target strength (TS; dB re 1 m^2), indexed by time and geographic positions provided by GPS receivers, were stored in Simrad-Kongsberg .raw format with a 1-GB maximum file size. During daytime, the echosounders operated in CW mode and logged to 60 m beyond the detected seabed range or to a maximum range of 500, 500, 500, 300, and 150 m for 38, 70, 120, 200, and 333 kHz, respectively. During nighttime, the echosounders operated in FM mode and logged to 100 m. For each acoustic instrument, the prefix for each file name is a concatenation of the survey name (e.g., 2307RL), the operational mode (CW or FM), and the logging commencement date and time from the EK80 software (v21.15.1). For example, a file generated by the Simrad-Kongsberg EK80 software for a WBT operated in CW mode is named `2307RL_CW-D20220826-T155651.raw`.

To minimize acoustic interference on *Lasker* and *Shimada*, transmit pulses from the EK80s, acoustic Doppler current profiler and echosounder (Simrad-Kongsberg EC150-3C), multibeam echosounder (Simrad-Kongsberg ME70), imaging sonar (Simrad-Kongsberg MS70), scanning sonar (Simrad-Kongsberg SX90), and a separate acoustic Doppler current profiler (Teledyne RD Instruments OS75 ADCP) were triggered using a synchronization system (Simrad K-Sync; Kongsberg). The K-Sync trigger rate, and thus the echosounder ping interval, was modulated by the EAL using the 18-kHz seabed depth provided by the Scientific Computing System (SCS). The EK80, EC150-3C, ME70, MS70, and ADCP were operated continuously, while the SX90 was only operated during daytime when CPS were observed in the area. All other instruments capable of producing sound within the EK80's CW bandwidths were secured during daytime survey operations. Exceptions were made during stations (e.g., plankton sampling and fish trawling) or in shallow water when the vessel's command occasionally operated the bridge's 50- and 200-kHz echosounders (Furuno), the Doppler velocity log (Model SRD-500A, Sperry Marine), or both.

On *Lisa Marie* and *Long Beach Carnage*, the EAL was used to control the EK80 software to modulate the echosounder recording ranges and ping intervals to avoid aliased seabed echoes. When the EAL was not utilized, the EK80 software recorded to 1000 m and used the maximum ping rate. Transmit pulses from the echosounders and fishing sonars were not synchronized. Therefore, the latter was secured during daytime acoustic transects.

On the USVs, the echosounders were programmed to transmit CW pulses to a range dependent on the transect depth. For deeper seabed depths, the ping interval was 2 s and the 38 and 200-kHz echosounders recorded to 1000 and 400 m, respectively. For shallower depths, the ping interval was 1 s and both echosounders recorded to 250 m. Once an hour, the echosounders would operate in passive mode and record three pings to obtain estimates of the background noise level.

[1]http://timesynctool.com
[2]https://www.fisheries.noaa.gov/west-coast/science-data/ek80-adaptive-logger/

2.2.4 Data processing

Echoes from schooling CPS (**Figs. 7a, d**) were identified using a semi-automated data processing algorithm implemented using Echoview software (v13.1; Echoview Software Pty Ltd). The filters and thresholds were based on a subsample of echoes from randomly selected CPS schools. The aim of the filter criteria is to retain at least 95% of the noise-free backscatter from CPS while rejecting at least 95% of the non-CPS backscatter (**Fig. 7**). Data from *Lasker*, *Shimada*, *Lisa Marie*, and *Long Beach Carnage* were processed using the following steps:

1. Match geometry of all S_v variables to the 38-kHz S_v;
2. Remove passive-mode pings;
3. Estimate and subtract background noise using the background noise removal function (De Robertis and Higginbottom, 2007) in Echoview (**Figs. 7b, e**);
4. Average the noise-free S_v echograms using non-overlapping 11-sample by 3-ping bins;
5. Expand the averaged, noise-reduced S_v echograms with a 7 pixel x 7 pixel dilation;
6. For each pixel, compute: $S_{v,200\text{kHz}} - S_{v,38\text{kHz}}$, $S_{v,120\text{kHz}} - S_{v,38\text{kHz}}$, and $S_{v,70\text{kHz}} - S_{v,38\text{kHz}}$;
7. Create a Boolean echogram for S_v differences in the CPS range: $-13.85 < S_{v,70\text{kHz}} - S_{v,38\text{kHz}} < 9.89$ and $-13.5 < S_{v,120\text{kHz}} - S_{v,38\text{kHz}} < 9.37$ and $-13.51 < S_{v,200\text{kHz}} - S_{v,38\text{kHz}} < 12.53$;
8. For 120 and 200 kHz, compute the squared difference between the noise-filtered S_v (Step 3) and averaged S_v (Step 4), average the results using an 11-sample by 3-ping window to derive variance, then compute the square root to derive the 120- and 200-kHz standard deviations ($\sigma_{120\text{kHz}}$ and $\sigma_{200\text{kHz}}$, respectively);
9. Expand the standard deviation echograms with a 7 pixel x 7 pixel dilation;
10. Create a Boolean echogram based on the standard deviations in the CPS range: $\sigma_{120\text{kHz}} >$ -65 dB and $\sigma_{200\text{kHz}} >$ -65 dB. Diffuse backscattering layers have low σ (Zwolinski *et al.*, 2010) whereas fish schools have high σ;
11. Intersect the two Boolean echograms to create an echogram with "TRUE" samples for candidate CPS schools and "FALSE" elsewhere;
12. Mask the noise-reduced echograms using the CPS Boolean echogram (**Figs. 7c, f**);
13. Create an integration-start line 5 m below the transducer (~10 m depth);
14. Create an integration-stop line 3 m above the estimated seabed (Demer *et al.*, 2009), or to the maximum logging range (e.g., 350 m), whichever is shallowest;
15. Set the minimum S_v threshold to -60 dB (corresponding to a density of approximately three 20-cm-long Pacific Sardine per 100 m^3);
16. Integrate the volume backscattering coefficients (s_V, m^2 m^{-3}) attributed to CPS over 5-m depths and averaged over 100-m distances;
17. Output the resulting nautical area scattering coefficients (s_A; m^2 nmi^{-2}) and associated information from each transect and frequency to comma-delimited text (.csv) files.

Data from the USVs were processed using the following steps:

1. Match geometry of the $S_{v,200\text{kHz}}$ to the $S_{v,38\text{kHz}}$;
2. Remove passive-mode pings;
3. Perform Steps 3-5 from *Lasker* processing;
4. For each pixel, compute: $S_{v,200\text{kHz}} - S_{v,38\text{kHz}}$;
5. Create a Boolean echogram for S_v differences in the CPS range: $-13.51 < S_{v,200\text{kHz}} - S_{v,38\text{kHz}} < 12.53$
6. Perform Steps 8-9 from *Lasker* processing for 200 kHz;
7. Create a Boolean echogram mask using $\sigma_{200\text{kHz}} >$ -57 dB;
8. Performs Steps 11-17 from *Lasker* processing.

When necessary, the start and stop integration lines were manually edited to exclude reverberation due to bubbles, to include the entirety of shallow CPS aggregations, or to exclude seabed echoes. Echoes suspected to be from rockfish or hake schools were also excluded based on the aggregation shapes and proximity to rocky seabed, or where diffuse schools were observed offshore either near the surface or deeper than ~250 m, respectively (**Fig. 8**).

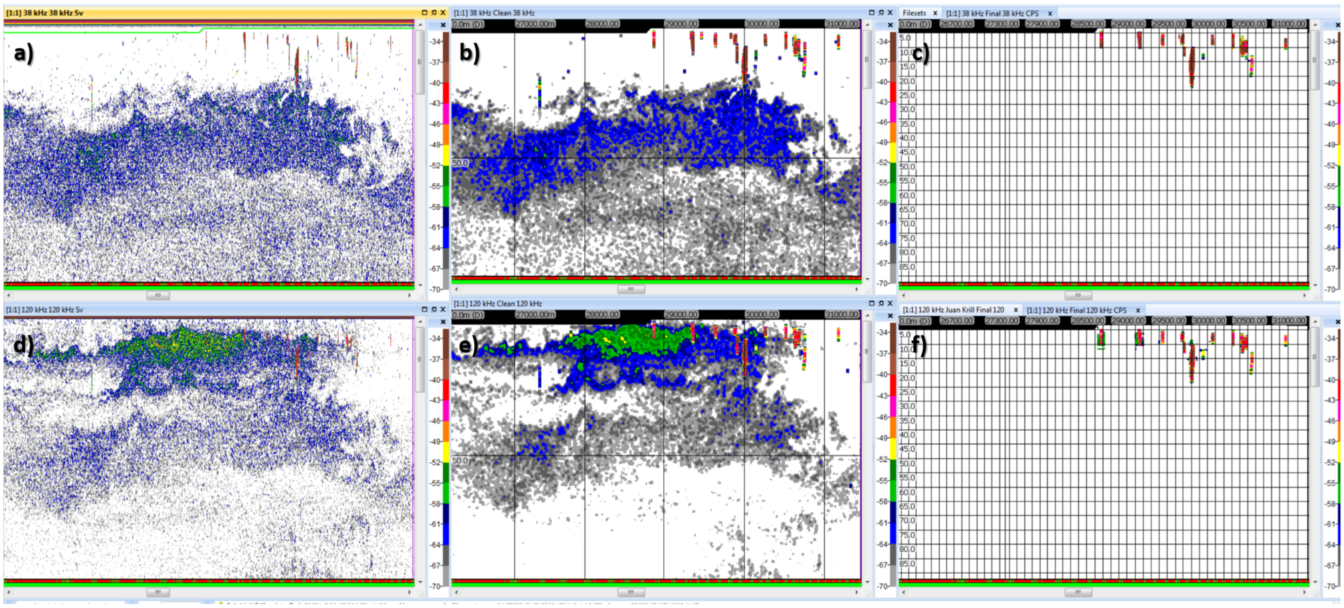

Figure 7: Echogram depicting CPS schools (red) and plankton aggregations (blue and green) at 38 kHz (top row) and 120 kHz (bottom row). Example data processing steps include the original echogram (left column; panels a and d), after noise subtraction and bin-averaging (middle column; panels b and e), and after filtering to retain only putative CPS echoes (right column; panels c and f).

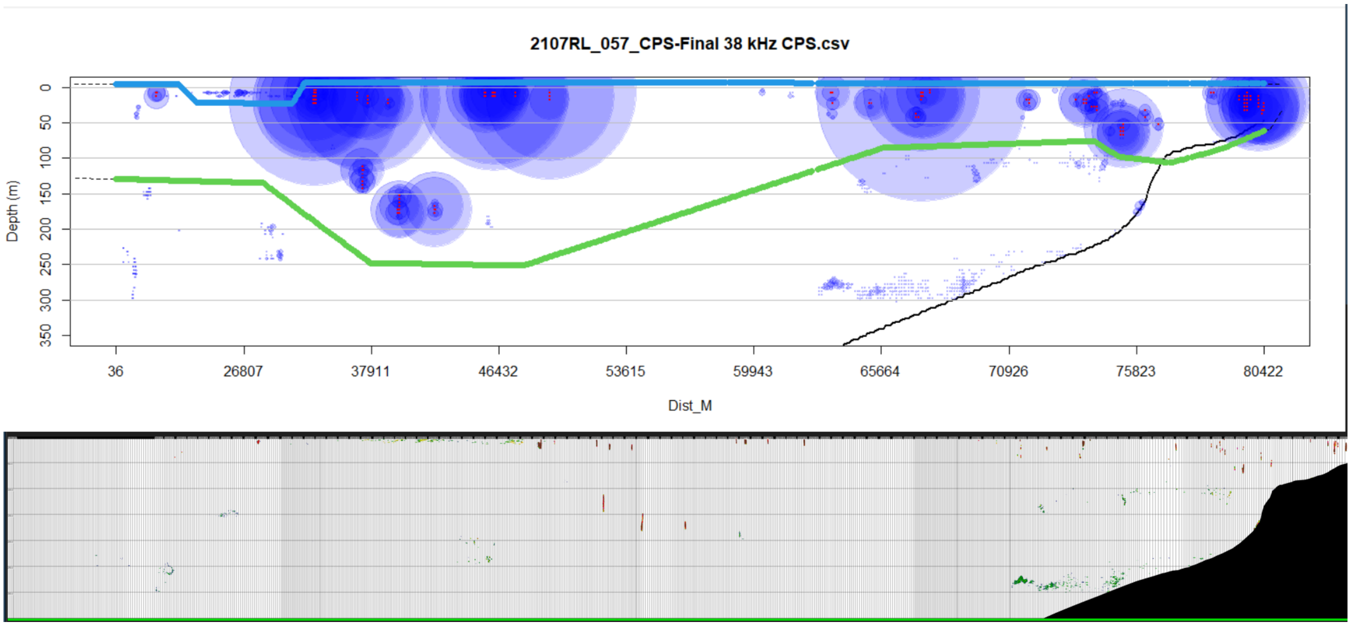

Figure 8: Echoes from fishes with swimbladders (blue points, scaled by backscatter intensity) along an example acoustic transect (top) and the corresponding echogram image (bottom). In this example, the upper (blue) and lower lines (green) indicate boundaries within which echoes were retained. When the lower boundary is deeper than the seabed (black line), echoes above the seabed are retained. Echoes from deep, bottom-dwelling schools of non-CPS fishes with swimbladders, and from diffuse scatterers near the surface were excluded. The proximity of the echoes to the seabed was also used to define the lower limit for vertical integration.

2.3 Trawl sampling

During the day, CPS form schools, typically in the upper mixed layer (e.g., down to 70-m depth in the spring, Kim *et al.*, 2005), and generally shallower in summer. After sunset, CPS schools tend to ascend and disperse; at that time, with reduced visibility and no schooling behavior, they are less able to avoid a net (Mais, 1974). Therefore, trawl sampling for identifying the species composition and length distributions of acoustic targets was performed at night.

On *Lasker* and *Shimada*, the net, a Nordic 264 rope trawl (NET Systems; Bainbridge Island, WA; **Figs. 9a, b**), has a rectangular opening in the fishing portion of the net with an area of approximately 300 m^2 (~15-m tall x 20-m wide), variable-sized mesh in the throat, an 8-mm square-mesh cod-end liner (to retain a large range of animal sizes), and a "marine mammal excluder device" to prevent the capture of larger animals, such as dolphins, turtles, or sharks (Dotson *et al.*, 2010). The trawl doors are foam-filled and the trawl headrope is lined with floats so the trawl opening spans from the surface to about 15-m depth.

Up to three nighttime (i.e., 60 min after sunset to 30 min before sunrise) surface trawls, typically spaced 5-10 nmi-apart, were conducted in areas where echoes from putative CPS schools were observed in echograms or eggs were observed in the CUFES earlier that day. Each evening, trawl locations were selected based on the acoustic and CUFES data using the following criteria, in descending priority: CPS schools in echograms that day, CPS eggs in CUFES samples that day, and the trawl locations and catches during the previous night. If no CPS echoes or CPS eggs were observed along the transect(s) that day, trawls were alternatively placed nearer to the coast one night and farther offshore the next night, with consideration given to the seabed depth and the modeled distribution of Pacific Sardine habitat.

Trawls were towed at ~4 kn for 45 min, excluding the deployment and haulback times. To the extent possible, the tow-track was curved in an arc-shaped pattern to keep the trawl outside of the vessel's wake. The total catch from each trawl was weighed and sorted by species or groups. From the catches with CPS, specimens were selected randomly for each of the target species, with up to 75 for Pacific Sardine and Northern Anchovy and up to 50 for Pacific Mackerel, Jack Mackerel, Round Herring, Pacific Hake, and Pacific Herring. Those were weighed and measured to either their standard length (L_S; mm) for Pacific Sardine and Northern Anchovy, or fork length (L_F; mm) for Jack Mackerel, Pacific Mackerel, Round Herring, Pacific Hake, and Pacific Herring. In addition, sex and maturity were visually determined and recorded for up to 50 specimens from Pacific Sardine and Pacific Hake and up to 25 for Northern Anchovy and Pacific and Jack Mackerels. For subsequent histological processing to validate maturity, ovaries were preserved of each CPS, except Round Herring, Pacific Hake, and Pacific Herring. For each CPS, ovaries (either whole or partial) were preserved for up to 10 specimens from each maturity code (immature specimens: maturity code 1; mature specimens: maturity codes 2-4). Fin clips were removed from all Pacific Sardine and 50 Northern Anchovy specimens each from seven different geographic zones (designated by J. Hyde and M. Craig, SWFSC) and preserved in ethanol for genetic analysis. Otoliths were removed from up to 50 Pacific Sardine and Pacific Hake in the subsample; for other CPS species (except Round Herring and Pacific Herring), 25 otoliths were removed from fish representing the range of lengths present, for age determination as described in Schwartzkopf *et al.* (2022) and Dorval *et al.* (2022). The combined catches of CPS in up to three trawls per night (i.e., trawl cluster) were used to estimate the proportions of species contributing to the nearest samples of acoustic backscatter.

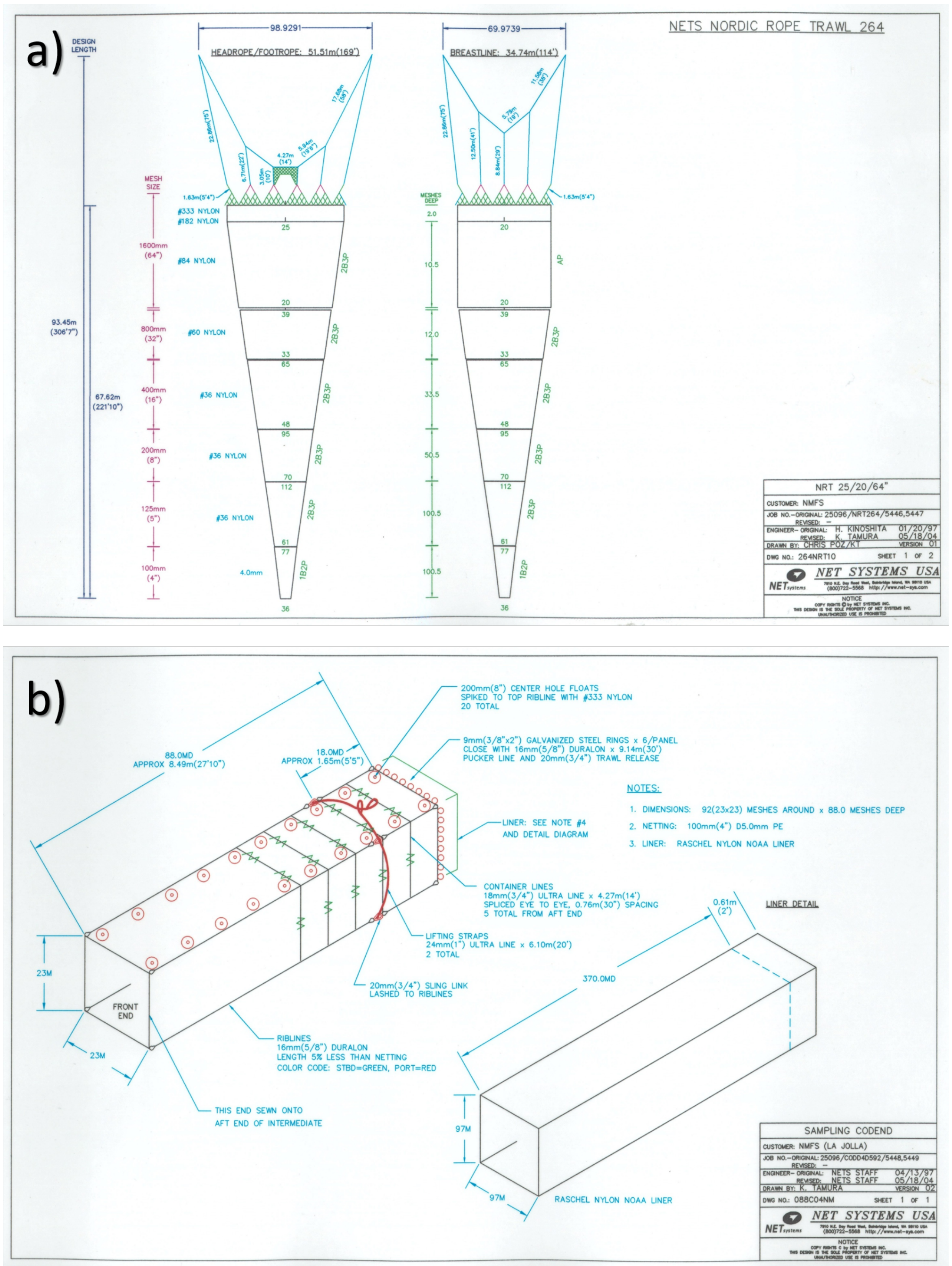

Figure 9: Schematic drawings of the Nordic 264 rope trawl net (a) and cod-end (b) used on *Lasker* and *Shimada*.

2.4 Purse seine sampling

Purse seine nets were set to provide information about size, age, and species composition of fishes observed in the echosounders mounted on the fishing vessels. *Lisa Marie* used an approximately 440-m-long and 40-m-deep net with 17-mm-wide mesh (A. Blair, pers. comm.). *Long Beach Carnage* used an approximately 200-m-long and 27-m-deep net with 17-mm-wide mesh; a small section on the back end of the net had 25-mm-wide mesh (R. Ashley, pers. comm.). Specimens collected by *Lisa Marie* and *Long Beach Carnage* were processed by the Washington Department of Fish and Wildlife (WDFW) and California Department of Fish and Wildlife (CDFW), respectively.

For the nearshore sampling on *Lisa Marie*, purse seine sets were planned for an average of one set per transect, or roughly 3-5 sets per day. The vessel was to run each transect in its entirety, then randomly set on an observed school. The seine was generally set during daytime, but could include nighttime in areas where schools were abundant, daytime sets were unsuccessful, or both. For each set, three dip net samples, spatially separated as much as possible, were collected. For each dip net sample, all specimens were sorted, weighed, and counted to provide a combined weight and count for each. Next, all three dip net samples were combined and up to 50 specimens of each species were randomly sampled to provide a combined weight for each set. For each individual CPS, the lengths (mm; L_S for Pacific Sardine and Northern Anchovy and L_F for all others) and weights were measured, otoliths extracted, and macroscopic maturity stage determined visually. Fin clips were collected for genetic analysis from all Pacific Sardine north of the California/Oregon border.

On *Long Beach Carnage*, purse seine sets were also planned for an average of one set per transect, or roughly 3-5 sets per day. The vessel was to run each transect in its entirety, then randomly set on an observed school. The seine was generally set during daytime, but could include nighttime in areas where schools were abundant, daytime sets were unsuccessful, or both. The total weight (tons) of the school was estimated by the captain. For each set, three dip net samples, spatially separated as much as possible, were collected. For each dip net sample, all specimens were sorted, weighed, and counted to provide a combined weight and count for each species. From each dip net sample, as many as 20 fish of each CPS species were chosen randomly throughout the sample, and combined for a random sample of 50 fish collected throughout the catch. The fish were then frozen for later analysis by CDFW biologists, yielding measures of total sample weight and individual fish weight, length (mm; L_S for Pacific Sardine and Northern Anchovy and L_F for all others), maturity, and otolith-derived ages. Because samples were frozen, no gonad samples from female specimens were analyzed.

2.5 Ichthyoplankton and oceanographic sampling

2.5.1 Egg and larva sampling

On *Lasker*, fish eggs were collected during the day using a CUFES, which collects water and plankton at a rate of ~640 l min^{-1} from an intake on the hull of the ship at ~3-m depth. The particles in the sampled water were sieved by a 505-μm mesh. Pacific Sardine, Northern Anchovy, Jack Mackerel, and Pacific Hake (*Merluccius productus*) eggs were identified to species, counted, and logged. Eggs from other species (e.g., Pacific Mackerel and flatfishes) were also counted and logged as "other fish eggs." Typically, the duration of each CUFES sample was 30 min, corresponding to a distance of 5 nmi at a speed of 10 kn, collected continuously both along the acoustic transects and during transits. Because the duration of the initial egg stages is short for most CPS, the egg distributions inferred from CUFES samples may indicate the nearby presence of actively spawning fish.

On *Lasker*, a CalCOFI bongo oblique net (a bridleless pair of 71-cm diameter nets with 505-μm mesh, Smith and Richardson, 1977) was used opportunistically to sample ichthyoplankton and krill after sunset, to contribute to the CalCOFI ichthyoplankton time series. Where there was adequate depth, 300 m of wire was deployed at a rate of 50 m min^{-1} and then retrieved at 20 m min^{-1}, at a nominal wire angle of 45°. Starboard-side samples were preserved in sodium borate-buffered 5% formalin.

2.5.2 Conductivity and temperature versus depth (CTD) sampling

On *Lasker* and *Shimada*, conductivity and temperature profiles were measured down to 300 m using calibrated sensors on a probe cast from the vessel while underway (UnderwayCTD, or UCTD; Teledyne Oceanscience). Casts were typically conducted between two to four times along each transect. These data indicate the depth of the surface mixed layer, above which most epipelagic CPS reside during the day. These data were also used to estimate the time-averaged sound speed (Demer, 2004), for estimating ranges to the sound scatterers, and frequency-specific sound absorption coefficients, for compensating signal attenuation of the sound pulse between the transducer and scatterers (Simmonds and MacLennan, 2005).

On *Lisa Marie* and *Long Beach Carnage*, conductivity and temperature profiles were measured down to 110 and 40 m using a Seabird SBE19plus or Teledyne Oceanscience UnderwayCTD, respectively. Casts were conducted from the vessels while stationary. The data were processed to obtain time-averaged sound speed values used for processing the acoustic data.

To process acoustic data from the USVs, conductivity and temperature profiles were obtained from CTD casts conducted by *Shimada* during the Northwest Fisheries Science Center's (NWFSC) 2023 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey, from 18 June to 15 September, 2023.

3 Results

3.1 Echosounder calibrations

For *Lasker*, the EK80s were calibrated on 27 June while the vessel was alongside the pier at 10th Avenue Marine Terminal, San Diego Bay (32.6956 °N, -117.15278 °W). Measurements of sea-surface temperature (t_w = 20.16 °C) and salinity (s_w = 34.11 psu) were measured to a depth of 10 m using a handheld probe (Pro2030, YSI) and input to the WBT-control software (EK80 v21.15.1, Simrad-Kongsberg), which derived estimates of sound speed and absorption coefficients. The centerboard was placed in the retracted position, which resulted in the seabed being approximately 6 to 10 m beneath the transducers, depending on the tide. The calibration spheres were positioned in the far-field of each transducer, at 3.5- to 7-m range. WBT information, settings, and calibration results are presented in **Table 1**. Measurements of beam-compensated sphere target strength relative to the theoretical target strength (TS_{rel}, dB re 1 m^2) are presented in **Fig. 10**. Measurements of gains, beamwidths, and offset angles from WBTs operated in FM mode are presented in **Fig. 11**.

Table 1: Wideband transceiver (Simrad EK80 WBT; Kongsberg) and transducer information aboard *Lasker* (above horizontal line); and beam model results following calibration (below horizontal line).

		Frequency (kHz)					
	Units	18	38	70	120	200	333
Model		ES18	ES38-7	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Serial Number		2106	337	233	783	513	124
Transmit Power (p_{et})	W	1000	2000	600	200	90	35
Pulse Duration (τ)	ms	1.024	1.024	1.024	1.024	1.024	1.024
Temperature	C	21.8	21.8	21.8	21.8	21.8	21.8
Salinity	ppt	35.0	35.0	35.0	35.0	35.0	35.0
Sound speed	m s^{-1}	1520.8	1520.8	1520.8	1520.8	1520.8	1520.8
On-axis Gain (G_0)	dB re 1	22.93	26.09	27.42	26.51	26.46	25.76
S_{a} Correction (S_{a}corr)	dB re 1	-0.01	-0.27	-0.07	-0.08	-0.05	-0.34
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	10.75	6.67	6.86	6.55	6.52	6.71
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	10.71	6.70	6.82	6.69	6.50	6.56
Angle Offset Along. (α_0)	deg	-0.00	0.08	-0.01	0.00	-0.02	0.03
Angle Offset Athw. (β_0)	deg	-0.02	-0.07	-0.04	0.03	0.10	0.01
Equivalent Two-way Beam Angle (Ψ)	dB re 1 sr	-16.94	-20.23	-20.22	-20.13	-20.12	-19.59
RMS	dB re 1	0.11	0.13	0.16	0.17	0.24	0.25

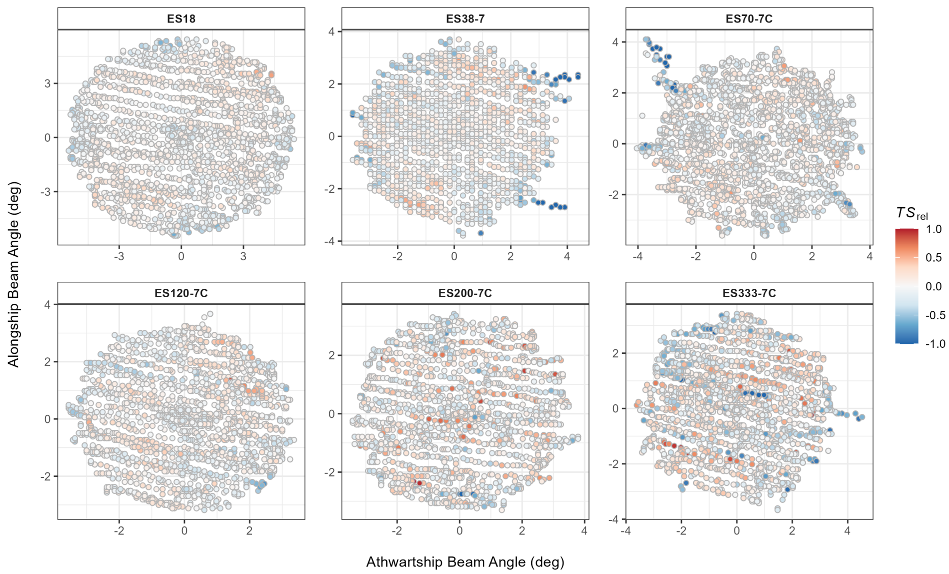

Figure 10: Relative beam-compensated target strength (TS_{rel}, dB re 1 m^2) measurements of a WC38.1 sphere at 18, 38, 70, 120, 200, and 333 kHz for echosounders aboard *Lasker*. TS_{rel} is calculated as the difference between the beam-compensated target strength (TS_c) and the theoretical target strength (TS_{theory}).

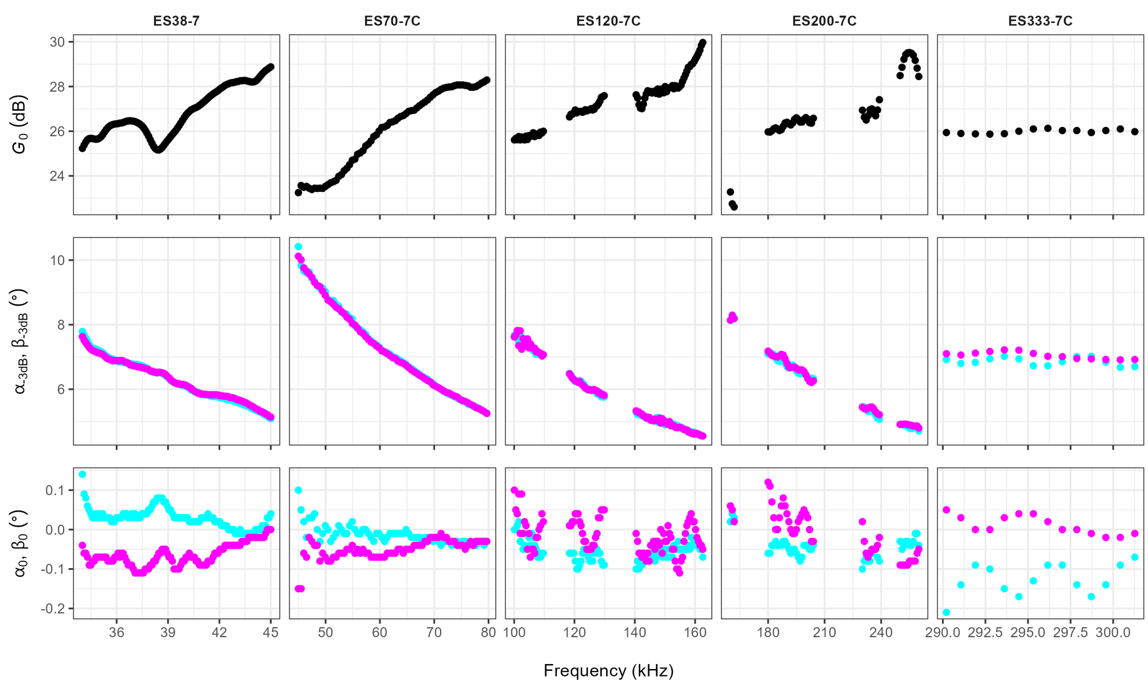

Figure 11: Measurements of on-axis gain (G_0, dB); alongship ($\alpha_{-3\mathrm{dB}}$, cyan) and athwartship ($\beta_{-3\mathrm{dB}}$, magenta) beamwidths (deg); and alongship (α_0, cyan) and athwartship (β_0, magenta) offset angles (deg) measured during calibrations of EK80 wideband transceivers aboard *Lasker* (WBT; 38, 70, 120, 200, and 333 kHz) in frequency modulation (FM, or broadband) mode.

For *Shimada*, the EK80s were calibrated by the NWFSC on 9 September in Seattle, WA after completing the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey. Calibration results for *Shimada* are presented in **Table 2**.

Table 2: Wideband Transceiver (Simrad EK80 WBT; Kongsberg) and transducer information (above horizontal line) and beam model results (below horizontal line) estimated from an in situ calibration of echosounders aboard *Shimada* using a WC38.1.

		Frequency (kHz)				
	Units	18	38	70	120	200
Model		ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Serial Number		2065	30715	168	573	339
Transmit Power (p_{et})	W	1000	2000	750	250	105
Pulse Duration (τ)	ms	1.024	1.024	1.024	1.024	1.024
Temperature	C	13.4	13.4	13.4	13.4	13.4
Salinity	ppt	33.7	33.7	33.7	33.7	33.7
Sound speed	m s^{-1}	1503.3	1503.3	1503.3	1503.3	1503.3
On-axis Gain (G_0)	dB re 1	22.96	26.53	28.10	26.76	28.03
S_{a} Correction (S_{a}corr)	dB re 1	-0.10	-0.09	-0.09	-0.14	-0.09
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	11.72	7.11	6.76	6.38	4.48
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	11.55	7.16	6.74	7.12	5.05
Angle Offset Along. (α_0)	deg	-0.07	-0.17	-0.06	-0.10	-0.33
Angle Offset Athw. (β_0)	deg	0.16	-0.14	0.06	0.20	0.57
Equivalent Two-way Beam Angle (Ψ)	dB re 1 sr	-17.26	-20.78	-20.64	-20.31	-20.07
RMS	dB re 1	0.58	0.11	0.13	0.42	1.13

For *Lisa Marie*, the EK80 WBTs were calibrated on 12 June using the standard sphere technique with a WC38.1 while the vessel was anchored in Gig Harbor, WA (47.32212 °N, 122.57275 °W). Calibration results for *Lisa Marie* are presented in **Table 3**.

Table 3: Wideband Transceiver (Simrad EK80 WBT; Kongsberg) and transducer information (above horizontal line) and beam model results (below horizontal line) estimated from an in situ calibration of echosounders aboard *Lisa Marie* using a WC38.1.

		Frequency (kHz)			
	Units	38	70	120	200
Model		ES38-7	ES70-7C	ES120-7C	ES200-7C
Serial Number		448	761	2355	899
Transmit Power (p_{et})	W	2000	600	200	90
Pulse Duration (τ)	ms	1.024	1.024	1.024	1.024
Temperature	C	11.7	11.7	11.7	11.7
Salinity	ppt	29.3	29.3	29.3	29.3
Sound speed	m s^{-1}	1488.9	1488.9	1488.9	1488.9
On-axis Gain (G_0)	dB re 1	25.42	27.71	26.57	26.73
S_{a} Correction (S_{a}corr)	dB re 1	-0.04	-0.08	-0.07	-0.13
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	6.71	6.97	6.71	6.38
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	6.77	6.94	6.72	6.32
Angle Offset Along. (α_0)	deg	-0.08	-0.02	0.03	-0.06
Angle Offset Athw. (β_0)	deg	-0.04	-0.04	-0.02	0.02
Equivalent Two-way Beam Angle (Ψ)	dB re 1 sr	-20.36	-20.47	-20.47	-20.46
RMS	dB re 1	0.14	0.17	0.23	0.17

For *Long Beach Carnage*, the echosounders were calibrated using the standard sphere technique with a WC38.1 on 18 April in a tank at the SWFSC. Calibration results for *Long Beach Carnage* are presented in **Table 4**.

Table 4: General Purpose Transceiver (Simrad EK60 GPT; Kongsberg) and transducer information (above horizontal line) and beam model results (below horizontal line) estimated from a tank calibration of echosounders aboard *Long Beach Carnage* using a WC38.1.

	Units	Frequency (kHz)			
		38	70	120	200
Model		ES38-12	ES70-7C	ES120-7C	ES200-7C
Serial Number		28075	234	813	616
Transmit Power (p_{et})	W	1000	600	200	90
Pulse Duration (τ)	ms	1.024	1.024	1.024	1.024
Temperature	C	18.5	18.5	18.5	18.5
Salinity	ppt	36.0	36.0	36.0	36.0
Sound speed	m s^{-1}	1518.5	1518.5	1518.5	1518.5
On-axis Gain (G_0)	dB re 1	21.79	26.24	26.25	26.63
S_{a} Correction (S_{a}corr)	dB re 1	-0.65	-0.32	-0.40	-0.21
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	12.50	6.74	6.79	6.80
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	12.61	6.70	6.84	6.83
Angle Offset Along. (α_0)	deg	0.01	0.04	0.17	-0.07
Angle Offset Athw. (β_0)	deg	0.12	0.00	-0.01	0.07
Equivalent Two-way Beam Angle (Ψ)	dB re 1 sr	-15.50	-20.70	-20.70	-20.06
RMS	dB re 1	0.04	0.04	0.07	0.08

For the three USVs, the echosounders were calibrated while dockside by Saildrone, Inc. using the standard sphere technique with a WC38.1. The results were processed and derived by the SWFSC using the methods described in Renfree *et al.* (2019), and are presented in **Table 5**.

Table 5: Miniature Wideband Transceiver (Simrad-Kongsberg WBT Mini) beam model results estimated from calibrations of echosounders aboard USVs using a WC38.1.

	Units	Saildrone (Frequency, in kHz)					
		1048 (38)	1048 (200)	1060 (38)	1060 (200)	1096 (38)	1096 (200)
Echosounder SN		264028	264028	719362	719362	268636	268636
Transducer SN		126	126	131	131	136	136
Temperature	C	15.9	15.9	17.4	17.4	18.4	18.4
Salinity	ppt	21.9	21.9	23.9	23.9	23.3	23.3
Sound speed	m s^{-1}	1494.3	1494.3	1501.4	1501.4	1503.6	1503.6
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-12.4	-11.2	-12.6	-12.0	-12.5	-11.5
On-axis Gain (G_0)	dB re 1	19.10	19.45	19.04	19.44	18.96	19.50
S_{a} Correction (S_{a}corr)	dB re 1	0.04	0.00	-0.04	-0.05	0.03	0.12
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	18.3	20.6	17.8	19.8	18.1	20.3
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	18.2	21.5	17.8	18.6	18.2	20.4
Angle Offset Along. (α_0)	deg	0.3	0.2	0.2	0.5	0.0	0.6
Angle Offset Athw. (β_0)	deg	0.1	-0.1	-0.6	-0.3	-0.4	0.1
RMS	dB	0.21	0.50	0.16	0.44	0.20	0.42

3.2 Data collection

3.2.1 Acoustic and net sampling

Due to the cancellation of Leg I.1 and all of Leg II on *Lasker*, transects off Baja California, MX and Vancouver Island, BC were omitted. The core survey region thus spanned an area from approximately San Diego, CA to Cape Flattery, WA (**Figs. 12 and 16**). Apart from missing Vancouver Island, this mostly included the latitudinal extent of the potential habitat for the northern stock of Pacific Sardine at the time of the survey[3]. *Lasker* sampled from San Diego, CA to Cape Mendocino, CA, then *Shimada* sampled from Reedsport, OR to Cape Flattery, WA (**Fig. 12a**). The three USVs surveyed interstitial to *Lasker* and *Shimada* transects from Point Conception, CA to Santiago, WA (**Fig. 12b**). In total, *Lasker*, *Shimada*, and the three USVs sampled 106 east-west transects totaling 3,599 nmi, and conducted 81 Nordic trawls.

The nearshore region was surveyed by *Long Beach Carnage* and *Lisa Marie*, spanning an area from San Diego, CA to Cape Flattery, WA, including around Santa Cruz and Santa Catalina Islands (**Figs. 13 and 17**). The vessels completed 191 east-west transects totaling 1084 nmi and 108 purse seine sets.

Leg I

I.1

Canceled due to OMAO staffing shortages and a seawater leak aboard *Lasker*.

I.2

On 17 July, after a 14-d delay, *Lasker* departed from the 10th Avenue Marine Terminal in San Diego, CA at ~2000 (all times GMT). Prior to the transit, a calibration of the Simrad EC150-3C ADCP was conducted northwest of the sea buoy outside San Diego Bay (32.6598 N, 117.3833 W). Due to the departure delays, sampling off Baja California was canceled. The survey commenced on 18 July along transect 033 off Imperial Beach, CA. On the evening of 22 July, a scientist and member of the deck crew were embarked using *Lasker*'s small boat at Dana Point Harbor. On 29 July, *Lasker* ceased acoustic sampling after completing the nearshore portion of transect 57 off Morro Bay, CA. At ~1300 on 30 July, *Lasker* arrived at Pier 30/32 in San Francisco, CA, completing Leg I.

Nearshore

From 8 to 18 July, *Long Beach Carnage* sampled nearshore transects 1 to 38, between San Diego and Point Conception, CA, including around Santa Catalina and Santa Cruz Islands.

From 22 to 25 July, *Lisa Marie* conducted purse-seine sets to compare catches with nighttime and daytime trawls, between Point Conception and Monterey Bay.

From 21 to 30 July, two USVs (SD-1060 and SD-1096) sampled transects 52 to 70, from Point Conception to Half Moon Bay.

Leg II

Leg II on *Lasker* was canceled due to OMAO staffing shortages and cases of COVID-19.

Nearshore

[3]https://coastwatch.pfeg.noaa.gov/erddap/griddap/sardine_habitat_modis.html

From 7 to 16 August, *Long Beach Carnage* sampled nearshore transects 39 to 90, from Point Conception to Bodega Bay, CA.

From 6 to 8 August, *Lisa Marie* conducted purse-seine sets for comparative catch analyses between Point Conception, CA and San Luis Obispo, CA. Then, from 11 August to 2 September, *Lisa Marie* sampled nearshore transects 91 to 216, from Bodega Bay, CA to Cape Flattery, WA.

From 10 to 29 August, three USVs sampled transects 72 to 100, from Half Moon Bay, CA to Crescent City, CA.

Leg III

III.1

At ~2030 on 5 September, *Lasker* departed from 10th Avenue Marine Terminal, San Diego. At ~2100 UTC on 6 September, an acoustic lander was deployed at 34.43877 N, 120.54697 W, near Point Conception. At ~1400 on 7 September, acoustic sampling resumed along transect 57 off Morro Bay, CA. At ~0100 on 11 September, after completing acoustic transect 67, a scientist was embarked via a small boat transfer near Moss Landing, CA. On 12 September, after a crack was discovered in a freshwater anti-roll tank, an emergency trip was planned to Pier 30/32 in San Francisco, CA, with evening trawling operations en-route. However, while in transit to the first trawl location on transect 77, the S-Band RADAR unexpectedly stopped turning. As a result, the ship canceled the planned trawls on transects 079 and 77 and began the emergency transit to San Francisco, CA. The ship moored alongside pier 30/32 at ~1400 on 13 September. On 13 and 14 September, the ship's engineers patched the crack in the anti-roll tank, and the ship's Electronics Technician worked with RADAR technicians to fix the S-Band RADAR. At ~1430 on 15 September, the ship departed San Francisco, resumed daytime acoustic sampling on transect 81, then trawled that evening on transects 77 and 79. At ~0700 on 17 September, after finishing acoustic sampling on transect 89 and conducting one nighttime trawl, *Lasker* transited to San Francisco for a mid-leg crew transfer on 18 September.

III.2

At ~1800 on 21 September, *Lasker* departed from Pier 30/32 in San Francisco. On 21 September, a passive acoustic buoy, part of SWFSC's ADRIFT acoustic monitoring project, was safely recovered after its previously scheduled retrieval vessel experienced mechanical problems. During the transit, the leak in *Lasker*'s anti-roll tank reemerged, but the decision was made to continue the survey. At ~1815 on 22 September, *Lasker* resumed acoustic sampling along transect 091 off Petrolia, CA. On 22 September, transects 91 and 93 were sampled acoustically and two trawls conducted that evening. With a leaking anti-roll tank and unworkable weather conditions in the forecast, it was decided to cease survey operations on 23 September and return to Newport. At 1700 on 24 September, *Lasker* returned to the MOC-P Pier in Newport to end Leg III and conclude the 2023 Summer CCE survey aboard *Lasker*. On 24 and 25 September, survey equipment was demobilized and transferred ashore, awaiting mobilization of *Shimada* for Leg IV.

Nearshore

From 5 to 30 September, the three USVs sampled their final transects of the survey, 102 to 134, from Crescent City, CA to Santiago, WA.

Leg IV

IV.1

Due to inclement weather on 10 and 11 October, Leg IV.1 on *Shimada* was delayed by two days. At ~1900 on 12 October, *Shimada* departed from Newport and commenced acoustic sampling near Waldport along transect 117. Transects 121, 123, 125, and 127 were shortened to 40-nmi lengths due to weather conditions. At ~1100 on 16 October, after completing nighttime trawling, *Shimada* transited south to transect 115 to be closer to Newport in case weather conditions deteriorated. On 16 October, after completing the third trawl near Astoria, OR, the crew discovered that the main body of the trawl net was damaged. Due to the high sea state, the trawl net was not replaced while underway. At ~2100 on 17 October, during favorable bar conditions, *Shimada* arrived at the MOC-P pier in Newport, OR to complete Leg IV.1. The damaged trawl net was replace with a spare net between Legs IV.1 and IV.2.

IV.2

At ~1945 on 26 October, *Shimada* departed from the MOC-P pier in Newport and, due to poor weather conditions, commenced acoustic sampling nearby on transects 113 and 115 off Florence. Between 28 October and 2 November, *Shimada* sampled transects 129 to 141 between Astoria and Cape Flattery. At ~1800 on 3 November, *Shimada* arrived at Anacortes, WA to complete the 2023 survey.

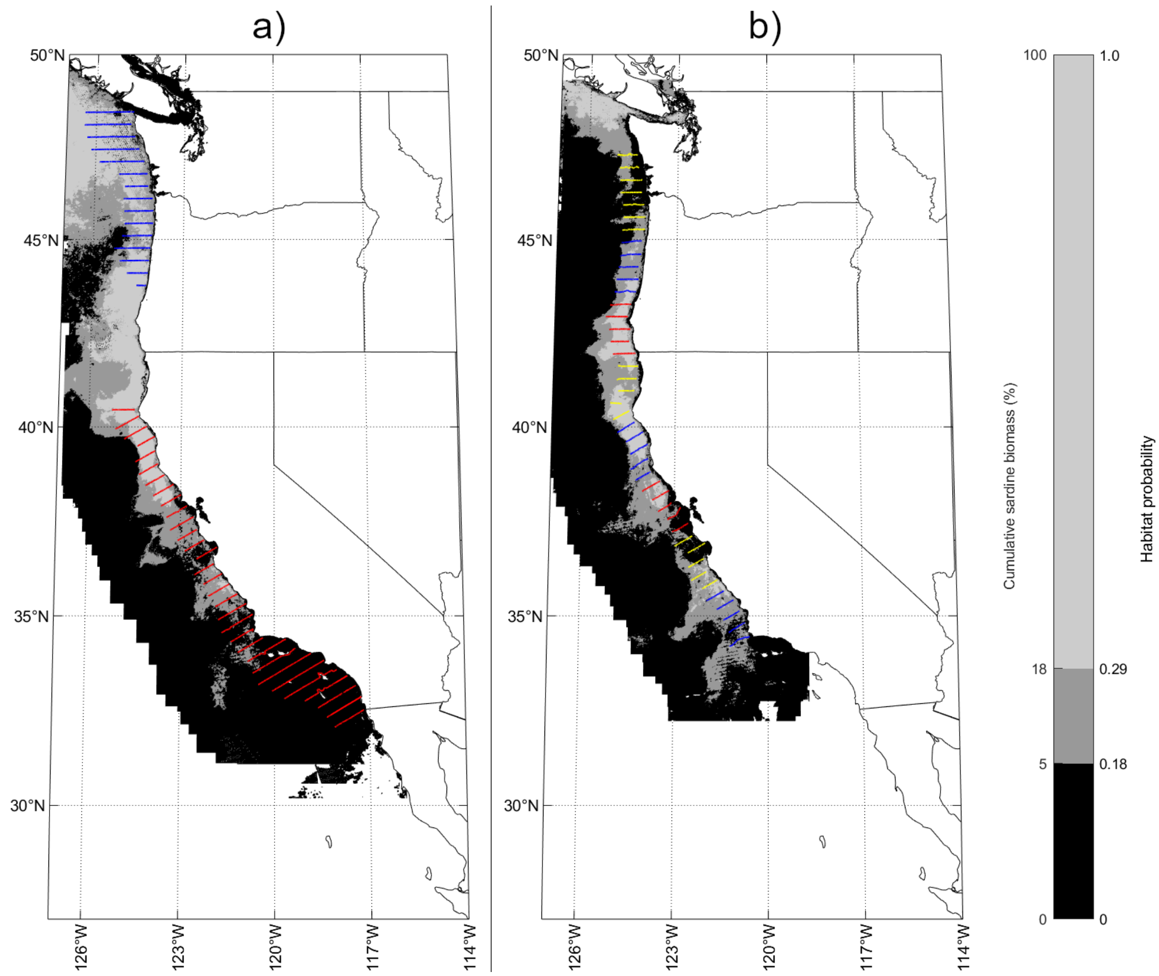

Figure 12: Core-region transects, in relation to the potential habitat for the northern stock of Pacific Sardine, as sampled by a) *Lasker* (red) and *Shimada* (blue); and b) Saildrone USVs SD-1048 (red), SD-1060 (blue), and SD-1096 (yellow). The habitat is temporally aggregated using an average of the habitat centered ±2° around each vessel during the survey. Areas in white correspond to no available data, e.g., cloud coverage preventing satellite-sensed observations.

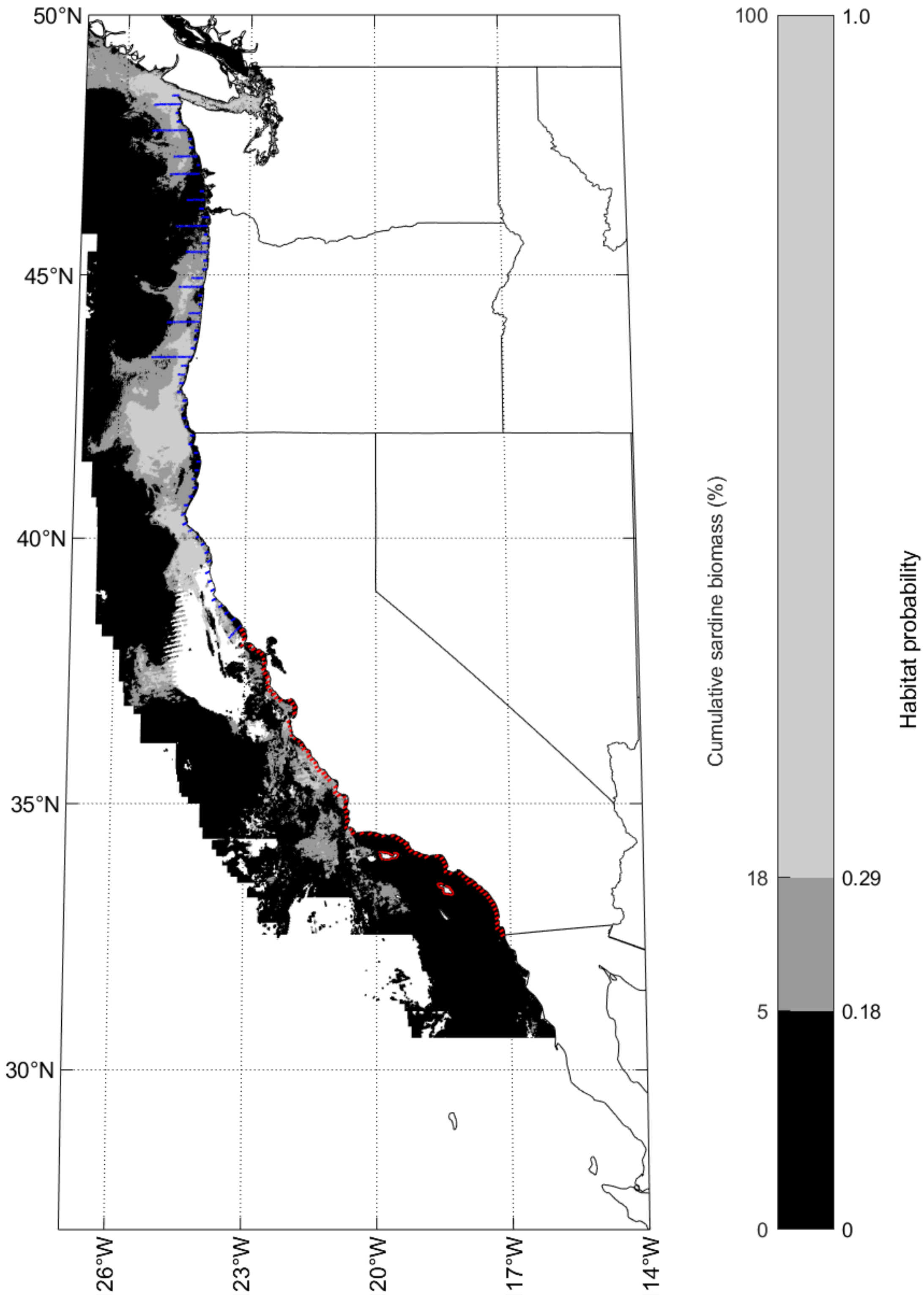

Figure 13: Nearshore-region transects sampled by *Long Beach Carnage* (red) and *Lisa Marie* (blue), in relation to the potential habitat for the northern stock of Pacific Sardine. The habitat is temporally aggregated using an average of the habitat centered $\pm 2°$ around each vessel during the survey. Areas in white correspond to no available data, e.g., cloud coverage preventing satellite-sensed observations.

3.2.2 Ichthyoplankton and oceanographic sampling

On *Lasker* a total of 67 UCTD casts (**Appendix B**), 8 bongo tows, and 555 CUFES samples were obtained (**Fig. 14**). During Leg IV on *Shimada*, a total of 19 UCTD casts were conducted; bongo tows and CUFES sampling were omitted due to personnel shortages.

On *Lisa Marie* and *Long Beach Carnage*, a total of 74 and 13 UCTD casts were conducted, respectively (**Fig. 15**).

A total of 199 CTD casts were obtained from the NWFSC's 2023 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey aboard *Shimada*, which were utilized for processing the USV transects (**Appendix B**).

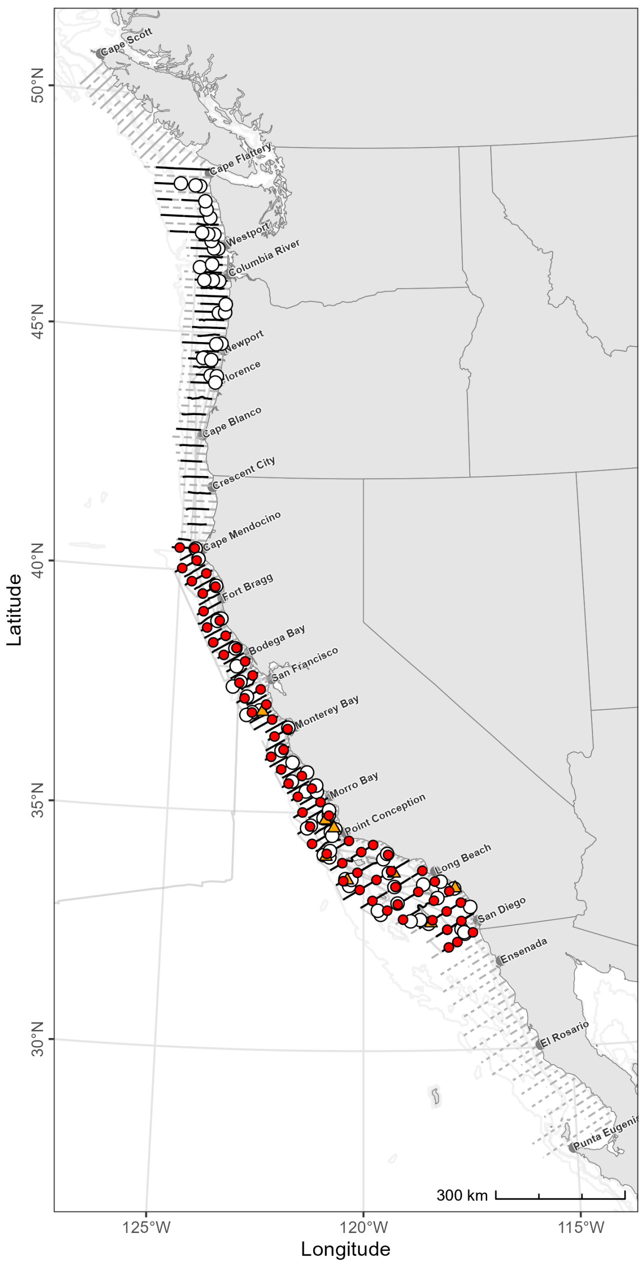

Figure 14: The locations of core-region surface trawls (white points), UCTD casts (red circles), and bongo nets (orange triangles) relative to the planned east-west acoustic transects (solid and dashed grey lines) and cruise tracks (thick black line) of *Lasker*, *Shimada*, and Saildrone USVs.

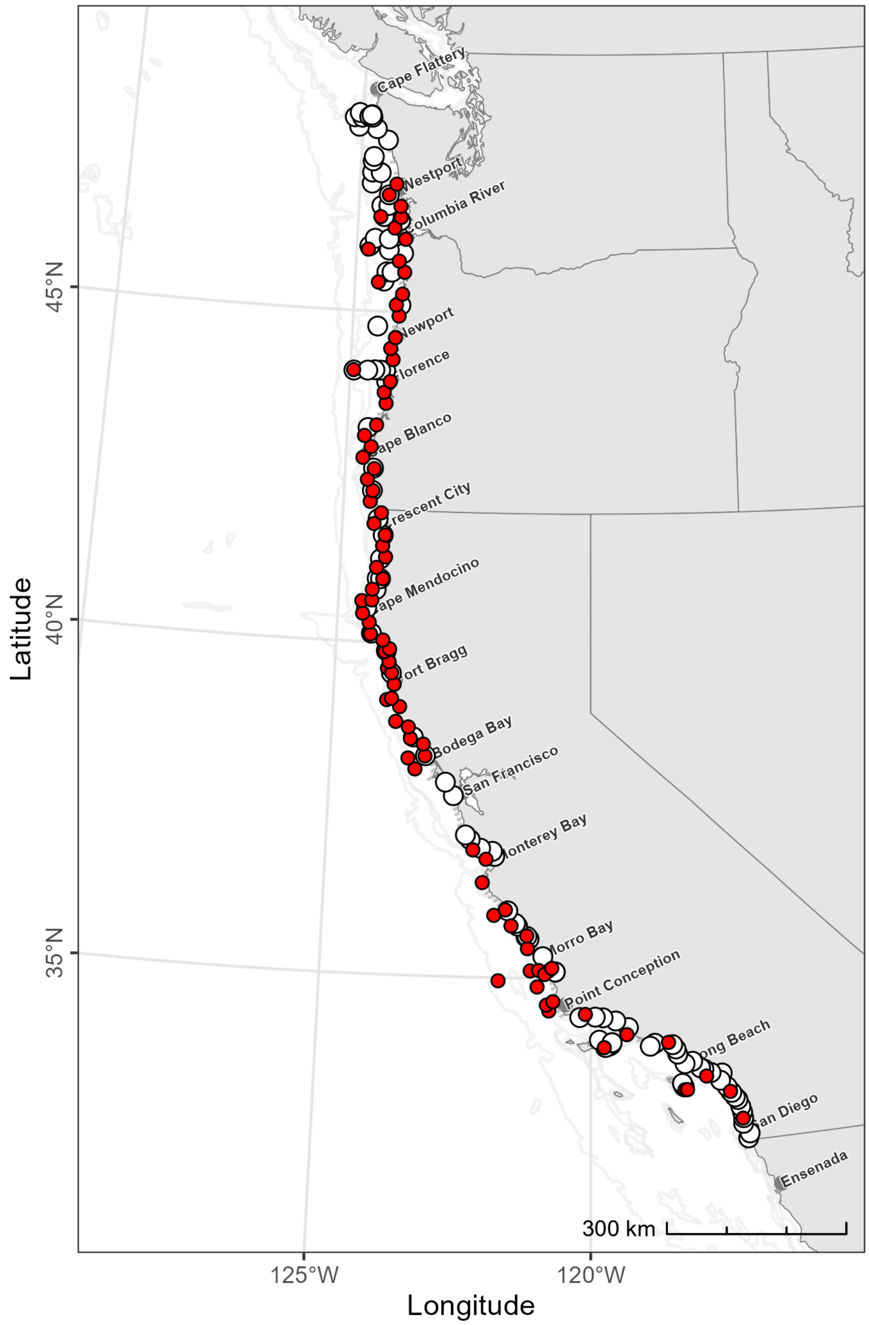

Figure 15: The locations of nearshore-region purse seine sets (white points) and UCTD casts (red circles) conducted by *Long Beach Carnage* and *Lisa Marie*.

3.3 Distribution of CPS

3.3.1 Core region

Acoustic backscatter ascribed to CPS in the core region (**Fig. 16a**), as sampled by *Lasker*, *Shimada*, and the USVs, was observed throughout the survey area, but was most prevalent between Cape Flattery, WA and Newport, OR, and between Fort Bragg and Point Conception, CA.

Surface trawls, conducted by *Lasker* to the south of Cape Mendocino, CA and to the north by *Shimada*, caught Pacific Sardine primarily in the region off OR and WA, as well as in the SCB; Northern Anchovy dominated trawl catches south of Cape Mendocino, CA; Jack Mackerel were observed throughout the survey area, but predominantly in the SCB and outside the mouth of the Columbia River; and Pacific Herring dominated trawl catches off OR and WA. The combined catches of the 81 trawls included 3,782 kg of CPS (99 kg Pacific Sardine, 3,524 kg Northern Anchovy, 59 kg Jack Mackerel, 0.9 kg Pacific Mackerel, and 99 kg Pacific Herring; **Appendix C**). Due to the lack of sampling off Baja California, MX, there were no catches of Round Herring.

CUFES samples were only collected south of Cape Mendocino, CA by *Lasker*, and consisted primarily of Northern Anchovy eggs north of Morro Bay, CA, Jack Mackerel eggs near Point Conception, CA, and a mixture of Northern Anchovy, Jack Mackerel, and Pacific Sardine eggs in the SCB (**Fig. 16b**). In the SCB, Northern Anchovy eggs were found predominantly nearshore while Pacific Sardine eggs were offshore.

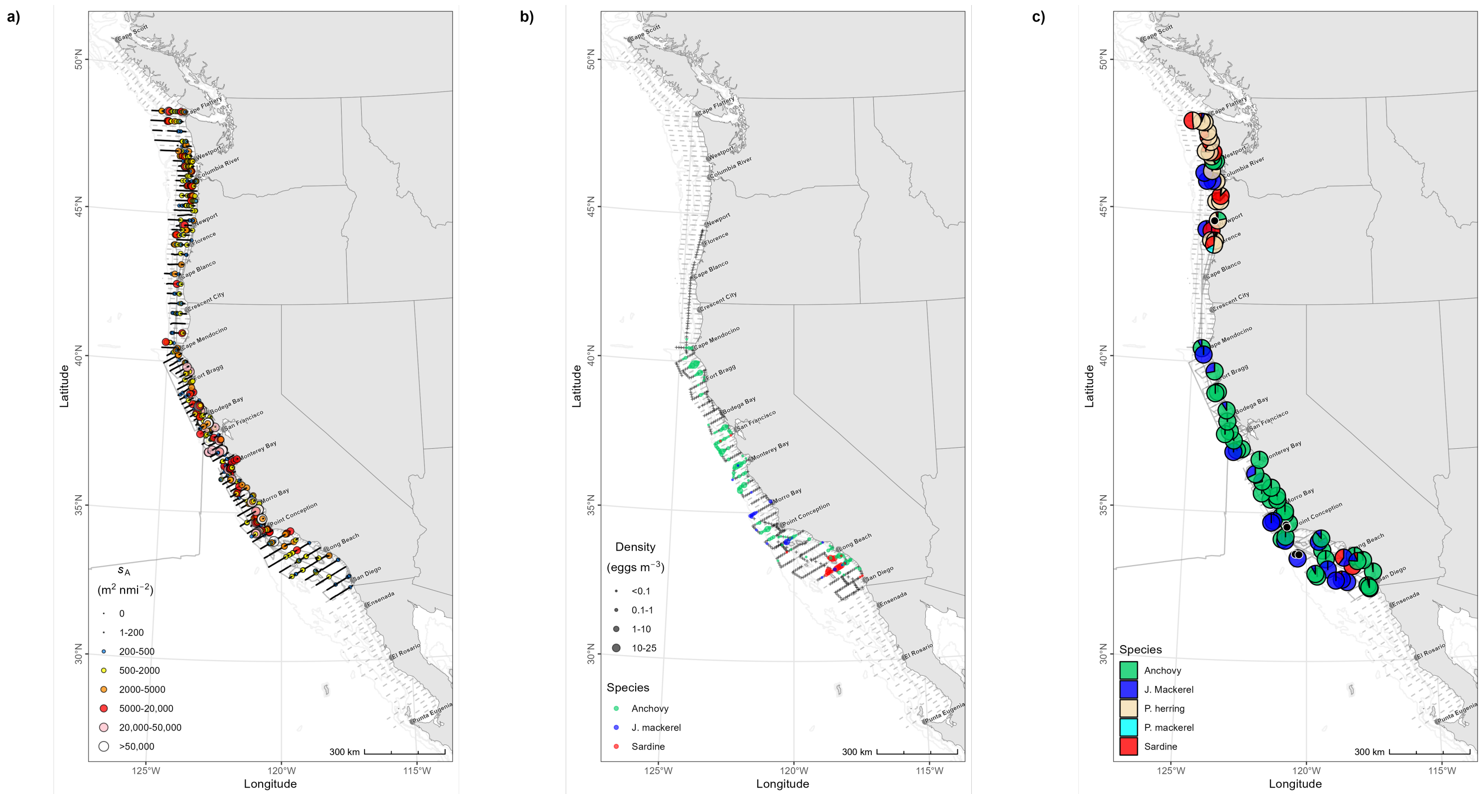

Figure 16: Survey transects overlaid with the distributions of: 38-kHz integrated backscattering coefficients (s_A, m^2 nmi^{-2}; averaged over 2000-m distance intervals and shallower than 350-m depth) ascribed to CPS (a); egg densities (eggs m^{-3}) for Northern Anchovy, Jack Mackerel, and Pacific Sardine from the CUFES (b); and proportions, by weight, of CPS species in each trawl catch (c; black points indicate trawls with no CPS). Species with low catch weights are not visible at this scale.

3.3.2 Nearshore region

Acoustic backscatter sampled by *Long Beach Carnage* and *Lisa Marie* was observed throughout the nearshore survey area, but was most prevalent north of Coos Bay, OR, between Santa Barbara, CA to Bodega Bay, CA, and around Santa Cruz Island (**Fig. 17a**).

Purse seine catches by *Long Beach Carnage* and *Lisa Marie* included predominantly Northern Anchovy between Fort Bragg and Long Beach, CA; Pacific Sardine north of Florence, OR and south of Monterey Bay, CA, including throughout the SCB and around the Santa Cruz and Santa Catalina Islands; Jack Mackerel north of Florence, OR and between Fort Bragg, CA to Crescent City, CA; Pacific Mackerel nearshore in the SCB and off Florence, OR; and Pacific Herring north of Cape Mendocino, CA (**Fig. 17b**). The combined catches of the 108 purse seine sets included 1,554 kg of CPS (926 kg Pacific Sardine, 270 kg Northern Anchovy, 173 kg Jack Mackerel, 110 kg Pacific Mackerel, and 75 kg Pacific Herring; **Appendix D.1 and D.2**). Purse seines conducted by *Lisa Marie* occurred during both day and night (**Fig. 18**).

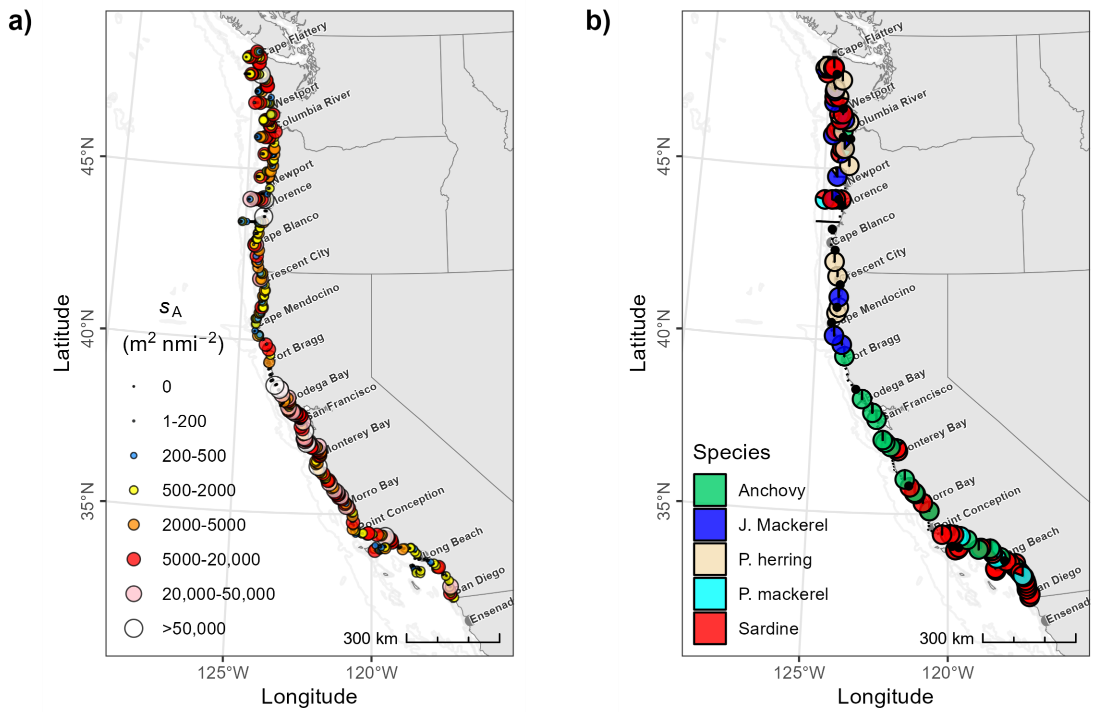

Figure 17: Nearshore survey transects conducted by *Long Beach Carnage* and *Lisa Marie* overlaid with the distributions of: 38-kHz integrated backscattering coefficients (s_A, m^2 nmi^{-2}; averaged over 2000-m distance intervals and shallower than 350-m depth) ascribed to CPS (a); and the proportions, by weight, of CPS in each purse seine catch (b; black points indicate trawls with no CPS). Species with low catch weights are not visible at this scale.

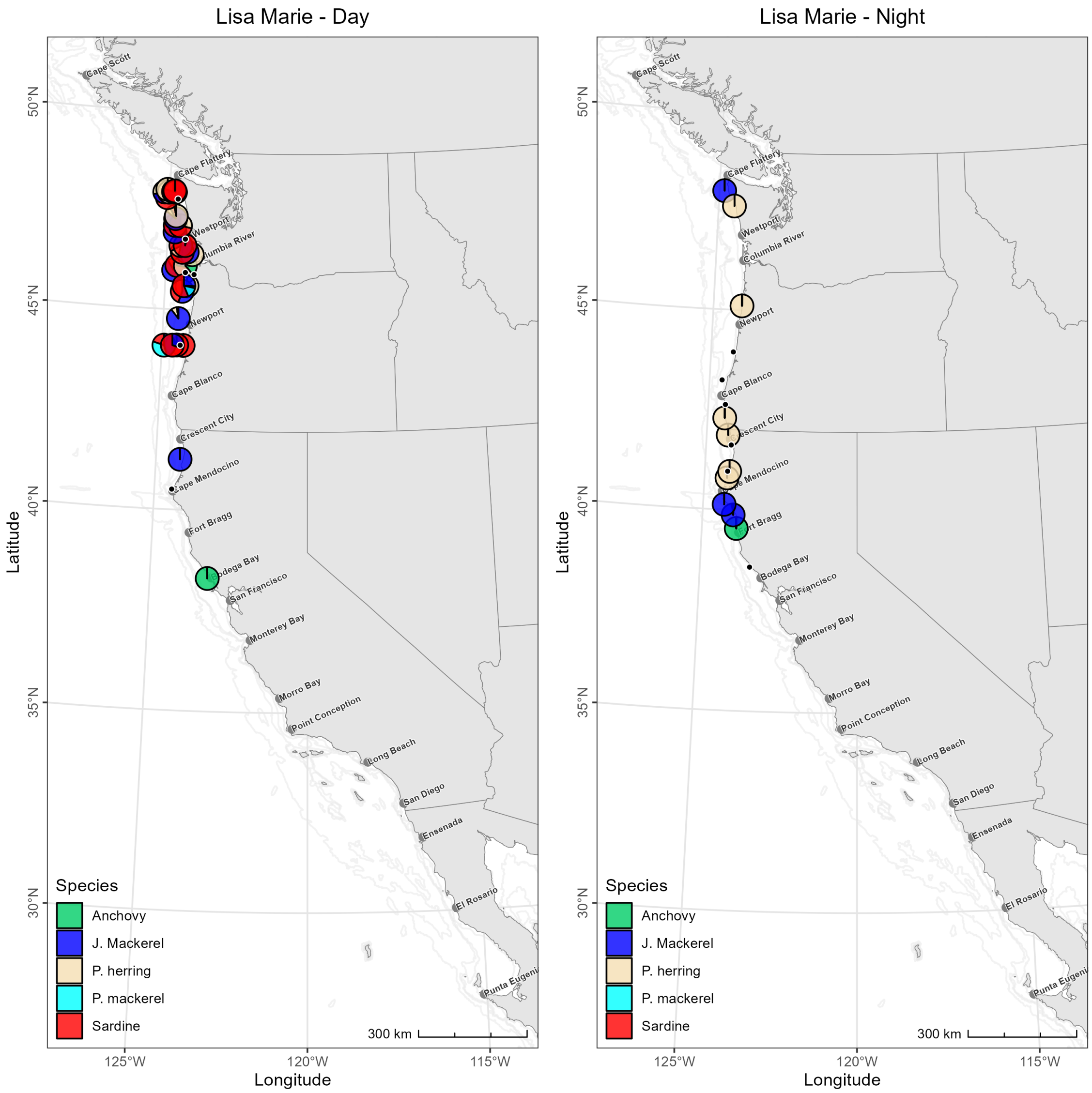

Figure 18: Proportions, by weight, of CPS species in each purse seine set conducted by *Lisa Marie* during daytime (left panel) and nighttime (right panel). Black points indicate purse seine sets with no CPS.

4 Discussion

The principal objectives of the Summer 2023 CCE Survey were to survey the stocks of Pacific Sardine, Northern Anchovy, Pacific Mackerel, Jack Mackerel, Pacific Herring, and Round Herring. Despite the original survey plan being substantially modified due to OMAO staffing issues on *Lasker*, the combined sampling from *Lasker*, *Shimada*, *Lisa Marie*, *Long Beach Carnage*, and Saildrone USVs spanned the offshore and nearshore areas from San Diego, CA to Cape Flattery, WA. This was made possible by the resilience and adaptability of all personnel from the various sampling platforms, who repeatedly had to modify the timing of their surveys, along with the NOAA scientists and crew who remained prepared and flexible throughout the uncertain survey schedule.

Due to the delays and cancellations on *Lasker*, no core-region trawl sampling was conducted between Cape Mendocino, CA and Reedsport, OR (**Fig. 16a**). Furthermore, sampling off Baja California, MX was only conducted by *Carranza*, and presented in a separate report by IMIPAS (Vallarta-Zárate *et al.*, 2023). Meanwhile, the nearshore sampling by *Lisa Marie* and *Long Beach Carnage* was comprehensive of the US west coast. The purse seine and acoustic sampling conducted by *Lisa Marie* north of Cape Mendocino suggests that a small amount of CPS biomass resides in the unsampled core-region area between Cape Mendocino, CA and Reedsport, OR.

Lisa Marie conducted purse seine sets during both day and night throughout the survey, allowing for comparisons of the species composition and size distributions between the two time periods (**Fig. 18**). Although *Lisa Marie* also completed purse seine sets for comparative catch analyses with *Shimada* trawls, they occurred approximately one month apart and may not provide reliable comparisons. Any such results from either analysis are not presented here.

5 Disposition of Data

All raw EK60, EK80, ME70, MS70, SX90, and EC150-3C data, including the EK60 and EK80 calibration data, are archived on the SWFSC data server. For more information, contact: Josiah Renfree (Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, California, 92037, U.S.A.; phone: 858-546-5669; email: josiah.renfree@noaa.gov).

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Appendix

A Centerboard positions

Date, time, and vessel associated with changes to the position of the centerboard and transducer depth on *Lasker* (RL) and *Shimada* (SH).

Date Time	Vessel	Position
07/17/2023 21:05	RL	Intermediate
07/30/2023 11:20	RL	Retracted
09/05/2023 21:46	RL	Intermediate
09/13/2023 11:59	RL	Retracted
09/15/2023 16:54	RL	Intermediate
09/18/2023 19:09	RL	Retracted
09/21/2023 20:10	RL	Intermediate
09/24/2023 14:47	RL	Retracted
10/12/2023 19:57	SH	Intermediate
10/17/2023 01:11	SH	Retracted
10/26/2023 19:42	SH	Intermediate
11/02/2023 22:10	SH	Retracted

B CTD and UCTD sampling locations

Times and locations of conductivity and temperature versus depth casts while on station (CTD) and underway (UCTD) from *Lasker* (RL), *Shimada* (SH), *Lisa Marie* (LM), and *Long Beach Carnage* (LBC). Also included are CTD casts conducted by *Shimada* (SH Hake) during the NWFSC's 2023 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey, used for processing acoustic data from the USVs.

Vessel	Date Time	Cast Type	Latitude	Longitude
LBC	07/09/2023 04:35	CTD	32.8579	-117.2737
LBC	07/10/2023 02:38	CTD	33.2676	-117.4878
LBC	07/11/2023 02:45	CTD	33.5082	-117.9114
LBC	07/12/2023 02:16	CTD	33.3062	-118.3053
LBC	07/12/2023 16:42	CTD	33.3083	-118.2600
LBC	07/14/2023 05:14	CTD	34.0262	-118.5886
LBC	07/15/2023 04:30	CTD	34.1499	-119.3419
LBC	07/16/2023 04:58	CTD	33.9546	-119.7548
LBC	07/18/2023 19:37	CTD	34.4565	-120.0980
LBC	08/08/2023 03:44	CTD	35.1496	-120.7182
LBC	08/10/2023 03:57	CTD	35.6348	-121.1848
LBC	08/11/2023 00:42	CTD	36.0227	-121.5896
LBC	08/13/2023 17:35	CTD	36.9175	-122.2220
LM	07/22/2023 22:06	CTD	35.1078	-121.1145
LM	07/22/2023 23:56	CTD	35.1153	-120.9601
LM	07/23/2023 03:46	CTD	35.4425	-121.1695
LM	07/23/2023 21:13	CTD	35.7832	-121.4803
LM	07/24/2023 00:45	CTD	35.9372	-121.8036
LM	07/24/2023 14:28	CTD	36.4281	-122.0313
LM	07/25/2023 05:28	CTD	36.7803	-121.9706
LM	08/06/2023 22:42	CTD	34.5067	-120.7670
LM	08/07/2023 00:17	CTD	34.5938	-120.8113
LM	08/07/2023 01:54	CTD	34.6460	-120.6949
LM	08/07/2023 05:31	CTD	34.8670	-120.9848
LM	08/07/2023 20:04	CTD	35.1109	-120.7759
LM	08/07/2023 21:36	CTD	35.0561	-120.8492
LM	08/08/2023 03:56	CTD	34.9523	-121.7026
LM	08/10/2023 17:29	CTD	38.3121	-123.1816
LM	08/10/2023 21:47	CTD	38.1109	-123.3655
LM	08/11/2023 05:30	CTD	38.2720	-123.5064
LM	08/11/2023 08:04	CTD	38.4894	-123.2233
LM	08/11/2023 10:52	CTD	38.5667	-123.4726
LM	08/11/2023 13:25	CTD	38.7394	-123.5221
LM	08/11/2023 15:34	CTD	38.8163	-123.7694
LM	08/12/2023 04:36	CTD	39.1381	-123.9611
LM	08/12/2023 07:01	CTD	39.0409	-123.7054
LM	08/12/2023 09:23	CTD	39.1616	-123.8695
LM	08/12/2023 11:48	CTD	39.3741	-123.8289
LM	08/13/2023 04:15	CTD	39.6142	-123.9721
LM	08/13/2023 06:11	CTD	39.5442	-123.8854
LM	08/13/2023 09:24	CTD	39.7095	-123.9459
LM	08/13/2023 11:05	CTD	39.8620	-124.0365

(continued)

Vessel	Date Time	Cast Type	Latitude	Longitude
LM	08/13/2023 12:48	CTD	39.9049	-123.9476
LM	08/13/2023 14:18	CTD	40.0329	-124.0859
LM	08/14/2023 06:07	CTD	40.1148	-124.3596
LM	08/14/2023 06:28	CTD	40.1168	-124.3336
LM	08/14/2023 09:54	CTD	40.2921	-124.3702
LM	08/14/2023 12:49	CTD	40.4247	-124.5070
LM	08/15/2023 05:33	CTD	40.6127	-124.5338
LM	08/15/2023 07:24	CTD	40.6289	-124.3375
LM	08/15/2023 09:17	CTD	40.7918	-124.3376
LM	08/16/2023 11:21	CTD	40.9556	-124.1395
LM	08/16/2023 13:28	CTD	41.1237	-124.2727
LM	08/16/2023 16:19	CTD	41.2872	-124.1034
LM	08/17/2023 06:03	CTD	41.4524	-124.1710
LM	08/17/2023 08:30	CTD	41.6177	-124.1300
LM	08/17/2023 11:20	CTD	41.7832	-124.3634
LM	08/17/2023 14:21	CTD	41.9494	-124.2244
LM	08/22/2023 06:29	CTD	42.1159	-124.4613
LM	08/22/2023 08:35	CTD	42.2794	-124.4176
LM	08/22/2023 10:46	CTD	42.4459	-124.5399
LM	08/22/2023 12:48	CTD	42.6121	-124.4105
LM	08/22/2023 15:49	CTD	42.7750	-124.6511
LM	08/23/2023 06:46	CTD	42.9421	-124.4948
LM	08/23/2023 09:25	CTD	43.1068	-124.6412
LM	08/23/2023 12:31	CTD	43.2748	-124.4051
LM	08/24/2023 06:51	CTD	43.6078	-124.2299
LM	08/24/2023 08:58	CTD	43.7730	-124.2788
LM	08/24/2023 11:44	CTD	43.9407	-124.1616
LM	08/24/2023 20:13	CTD	44.0939	-124.9343
LM	08/25/2023 09:04	CTD	44.2739	-124.1241
LM	08/25/2023 10:51	CTD	44.4414	-124.1833
LM	08/25/2023 12:45	CTD	44.6081	-124.0951
LM	08/26/2023 08:21	CTD	44.9391	-124.0376
LM	08/26/2023 10:55	CTD	45.1057	-124.1043
LM	08/26/2023 13:12	CTD	45.2742	-123.9836
LM	08/26/2023 17:52	CTD	45.4422	-124.5059
LM	08/27/2023 10:15	CTD	45.6078	-123.9576
LM	08/27/2023 12:22	CTD	45.7736	-124.0832
LM	08/27/2023 19:42	CTD	45.9351	-124.7538
LM	08/28/2023 11:27	CTD	46.1106	-123.9642
LM	08/28/2023 14:02	CTD	46.2747	-124.2058
LM	08/28/2023 16:49	CTD	46.4420	-124.0777
LM	08/28/2023 20:29	CTD	46.4392	-124.5202
LM	08/29/2023 10:24	CTD	46.6101	-124.0967
LM	08/29/2023 14:06	CTD	46.7781	-124.3595
LM	08/29/2023 15:42	CTD	46.9457	-124.2062
RL	07/17/2023 23:24	UCTD	32.4691	-117.2963
RL	07/18/2023 02:44	UCTD	32.7144	-117.5753
RL	07/18/2023 17:05	UCTD	33.0994	-117.5769

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Vessel	Date Time	Cast Type	Latitude	Longitude
RL	07/18/2023 19:40	UCTD	32.9220	-117.9345
RL	07/19/2023 13:10	UCTD	32.2732	-117.6869
RL	07/19/2023 14:31	UCTD	32.1649	-117.9010
RL	07/19/2023 20:38	UCTD	32.5369	-117.9294
RL	07/19/2023 20:38	UCTD	32.5369	-117.9294
RL	07/20/2023 00:45	UCTD	32.7429	-118.2906
RL	07/20/2023 13:26	UCTD	32.7636	-119.0190
RL	07/20/2023 19:41	UCTD	33.1525	-118.2454
RL	07/20/2023 22:32	UCTD	33.3441	-117.8600
RL	07/21/2023 17:24	UCTD	33.5529	-118.2136
RL	07/21/2023 23:48	UCTD	33.7839	-118.5226
RL	07/22/2023 18:25	UCTD	33.7836	-119.3067
RL	07/22/2023 20:38	UCTD	33.6012	-119.6750
RL	07/23/2023 00:34	UCTD	33.4503	-119.2012
RL	07/23/2023 15:46	UCTD	33.3426	-118.6319
RL	07/23/2023 18:57	UCTD	33.0845	-119.1478
RL	07/23/2023 20:31	UCTD	32.9552	-119.4099
RL	07/24/2023 02:18	UCTD	33.1608	-119.7774
RL	07/24/2023 21:16	UCTD	33.3911	-120.0970
RL	07/25/2023 02:56	UCTD	33.5746	-120.5065
RL	07/25/2023 16:25	UCTD	33.9515	-120.5327
RL	07/26/2023 00:36	UCTD	34.1450	-120.9266
RL	07/26/2023 22:05	UCTD	33.7515	-120.1526
RL	07/27/2023 02:54	UCTD	34.1266	-119.3794
RL	07/27/2023 15:05	UCTD	34.3335	-119.7561
RL	07/27/2023 16:51	UCTD	34.1859	-120.0558
RL	07/27/2023 22:45	UCTD	34.4186	-120.3677
RL	07/28/2023 16:02	UCTD	34.3500	-121.3005
RL	07/28/2023 21:17	UCTD	34.7126	-121.3573
RL	07/29/2023 00:00	UCTD	34.9454	-120.8811
RL	09/07/2023 16:46	UCTD	35.0050	-121.5552
RL	09/07/2023 19:38	UCTD	35.2267	-121.1000
RL	09/07/2023 23:55	UCTD	35.5094	-121.3263
RL	09/08/2023 01:59	UCTD	35.3325	-121.6808
RL	09/08/2023 15:25	UCTD	35.7683	-121.5865
RL	09/08/2023 17:34	UCTD	35.6042	-121.9245
RL	09/08/2023 21:35	UCTD	35.8974	-122.1221
RL	09/09/2023 15:33	UCTD	36.3096	-122.0737
RL	09/09/2023 17:26	UCTD	36.1574	-122.3897
RL	09/09/2023 22:06	UCTD	36.5834	-122.3157
RL	09/10/2023 00:05	UCTD	36.7463	-121.9770
RL	09/10/2023 15:27	UCTD	36.9362	-122.3884
RL	09/10/2023 21:32	UCTD	37.0727	-122.9223
RL	09/10/2023 23:39	UCTD	37.2478	-122.5522
RL	09/11/2023 15:48	UCTD	37.3649	-123.1278
RL	09/11/2023 18:16	UCTD	37.5611	-122.7121
RL	09/11/2023 22:27	UCTD	37.8467	-122.9333

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Vessel	Date Time	Cast Type	Latitude	Longitude
RL	09/12/2023 00:31	UCTD	37.6844	-123.2770
RL	09/12/2023 18:06	UCTD	38.1354	-123.1455
RL	09/12/2023 21:53	UCTD	38.4094	-123.3887
RL	09/13/2023 00:25	UCTD	38.2559	-123.7184
RL	09/16/2023 00:34	UCTD	38.6574	-123.6876
RL	09/16/2023 02:14	UCTD	38.5088	-124.0128
RL	09/16/2023 17:31	UCTD	38.9681	-123.8633
RL	09/16/2023 19:30	UCTD	38.8143	-124.1936
RL	09/16/2023 23:30	UCTD	39.1514	-124.3083
RL	09/17/2023 15:33	UCTD	39.6763	-124.0165
RL	09/17/2023 18:23	UCTD	39.5205	-124.3526
RL	09/17/2023 22:50	UCTD	39.7685	-124.6628
RL	09/18/2023 00:51	UCTD	39.9442	-124.2808
RL	09/22/2023 19:27	UCTD	40.0309	-124.9423
RL	09/22/2023 21:29	UCTD	40.2062	-124.5590
RL	09/23/2023 00:05	UCTD	40.4592	-124.6289
RL	09/23/2023 01:54	UCTD	40.4581	-125.0407
SH	10/12/2023 22:11	UCTD	44.4393	-124.3867
SH	10/13/2023 00:45	UCTD	44.4363	-124.9825
SH	10/14/2023 00:00	UCTD	44.7672	-125.1979
SH	10/14/2023 00:00	UCTD	44.7672	-125.1979
SH	10/14/2023 15:48	UCTD	45.1071	-124.3212
SH	10/14/2023 18:51	UCTD	45.1013	-124.9768
SH	10/14/2023 21:05	UCTD	45.4323	-124.9694
SH	10/14/2023 23:41	UCTD	45.4402	-124.3176
SH	10/15/2023 15:48	UCTD	45.7739	-124.2921
SH	10/15/2023 18:29	UCTD	45.7693	-124.9157
SH	10/15/2023 22:09	UCTD	46.1061	-124.7160
SH	10/16/2023 00:17	UCTD	46.1083	-124.2238
SH	10/26/2023 23:38	UCTD	32.7718	-128.3182
SH	10/28/2023 21:15	UCTD	46.7720	-124.8916
SH	10/28/2023 23:16	UCTD	46.7760	-124.4211
SH	10/29/2023 16:59	UCTD	47.1085	-124.8956
SH	10/30/2023 20:26	UCTD	47.4346	-125.9299
SH	10/31/2023 20:58	UCTD	48.1114	-125.5291
SH	11/02/2023 19:18	UCTD	48.4471	-125.2330
SH Hake	06/27/2023 14:30	CTD	34.4475	-121.1811
SH Hake	06/27/2023 16:41	CTD	34.4461	-120.9668
SH Hake	06/27/2023 23:36	CTD	34.4440	-120.7411
SH Hake	06/28/2023 01:01	CTD	34.4391	-120.6717
SH Hake	06/28/2023 02:08	CTD	34.4453	-120.6150
SH Hake	06/28/2023 03:30	CTD	34.4468	-120.5026
SH Hake	06/28/2023 07:38	CTD	34.7783	-121.0726
SH Hake	06/28/2023 09:11	CTD	34.7798	-120.9380
SH Hake	06/28/2023 10:21	CTD	34.7791	-120.8458
SH Hake	06/28/2023 11:36	CTD	34.7800	-120.6972
SH Hake	06/29/2023 06:01	CTD	35.1104	-120.9670
SH Hake	06/29/2023 07:16	CTD	35.1120	-121.0742

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Vessel	Date Time	Cast Type	Latitude	Longitude
SH Hake	06/29/2023 09:33	CTD	35.1104	-121.3800
SH Hake	06/29/2023 11:52	CTD	35.1103	-121.7292
SH Hake	06/30/2023 05:35	CTD	35.4432	-121.5177
SH Hake	06/30/2023 07:32	CTD	35.4462	-121.3138
SH Hake	06/30/2023 09:03	CTD	35.4472	-121.1620
SH Hake	06/30/2023 10:06	CTD	35.4464	-121.0810
SH Hake	06/30/2023 11:02	CTD	35.4457	-121.0174
SH Hake	06/30/2023 17:08	CTD	35.4435	-121.1759
SH Hake	06/30/2023 21:29	CTD	35.4452	-121.9283
SH Hake	07/07/2023 04:12	CTD	35.7748	-122.2156
SH Hake	07/07/2023 08:27	CTD	35.7805	-121.5310
SH Hake	07/07/2023 09:30	CTD	35.7798	-121.4920
SH Hake	07/07/2023 10:26	CTD	35.7796	-121.4689
SH Hake	07/07/2023 11:28	CTD	35.7789	-121.3704
SH Hake	07/08/2023 00:56	CTD	36.1132	-121.6604
SH Hake	07/08/2023 01:38	CTD	36.1127	-121.6645
SH Hake	07/08/2023 02:32	CTD	36.1103	-121.6958
SH Hake	07/08/2023 08:04	CTD	36.4428	-121.9740
SH Hake	07/08/2023 08:44	CTD	36.4444	-121.9865
SH Hake	07/08/2023 09:33	CTD	36.4448	-122.0124
SH Hake	07/08/2023 12:20	CTD	36.4435	-122.3700
SH Hake	07/09/2023 02:16	CTD	36.7809	-122.3006
SH Hake	07/09/2023 03:46	CTD	36.7771	-122.2108
SH Hake	07/09/2023 05:18	CTD	36.7777	-122.1060
SH Hake	07/09/2023 06:49	CTD	36.7788	-122.0007
SH Hake	07/09/2023 08:09	CTD	36.7797	-121.8969
SH Hake	07/09/2023 09:05	CTD	36.7799	-121.8906
SH Hake	07/09/2023 09:49	CTD	36.7796	-121.8818
SH Hake	07/09/2023 10:33	CTD	36.7796	-121.8406
SH Hake	07/10/2023 06:13	CTD	37.4444	-123.2782
SH Hake	07/10/2023 07:30	CTD	37.4459	-123.2245
SH Hake	07/10/2023 08:58	CTD	37.4466	-123.1230
SH Hake	07/10/2023 10:08	CTD	37.4466	-123.0206
SH Hake	07/10/2023 11:31	CTD	37.4449	-122.5225
SH Hake	07/11/2023 04:42	CTD	37.7791	-123.4264
SH Hake	07/11/2023 05:52	CTD	37.7774	-123.3940
SH Hake	07/11/2023 07:27	CTD	37.7788	-123.2877
SH Hake	07/11/2023 08:23	CTD	37.7791	-123.2796
SH Hake	07/11/2023 09:15	CTD	37.7789	-123.2591
SH Hake	07/11/2023 11:58	CTD	37.7804	-122.8374
SH Hake	07/12/2023 05:06	CTD	38.1090	-123.3273
SH Hake	07/12/2023 06:41	CTD	38.1062	-123.4966
SH Hake	07/12/2023 07:36	CTD	38.1092	-123.5229
SH Hake	07/12/2023 08:58	CTD	38.1121	-123.6044
SH Hake	07/13/2023 05:39	CTD	38.4447	-123.4831
SH Hake	07/13/2023 06:52	CTD	38.4439	-123.6200
SH Hake	07/13/2023 07:36	CTD	38.4449	-123.6422

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Vessel	Date Time	Cast Type	Latitude	Longitude
SH Hake	07/13/2023 08:46	CTD	38.4465	-123.7181
SH Hake	07/13/2023 09:33	CTD	38.4460	-123.7475
SH Hake	07/13/2023 10:29	CTD	38.4464	-123.7845
SH Hake	07/13/2023 19:43	CTD	38.4460	-123.2205
SH Hake	07/14/2023 04:38	CTD	38.7779	-123.9917
SH Hake	07/14/2023 06:16	CTD	38.7772	-123.8732
SH Hake	07/14/2023 07:41	CTD	38.7750	-123.8536
SH Hake	07/14/2023 08:39	CTD	38.7785	-123.8198
SH Hake	07/14/2023 10:24	CTD	38.7793	-123.5915
SH Hake	07/15/2023 06:11	CTD	39.1117	-123.7495
SH Hake	07/15/2023 07:31	CTD	39.1100	-123.9413
SH Hake	07/15/2023 08:27	CTD	39.1114	-124.0173
SH Hake	07/15/2023 09:48	CTD	39.1114	-124.1164
SH Hake	07/16/2023 05:31	CTD	39.4465	-123.8500
SH Hake	07/16/2023 06:31	CTD	39.4434	-123.9499
SH Hake	07/16/2023 07:15	CTD	39.4440	-123.9822
SH Hake	07/16/2023 08:08	CTD	39.4441	-124.0125
SH Hake	07/16/2023 09:46	CTD	39.4454	-124.1211
SH Hake	07/16/2023 12:13	CTD	39.4455	-124.3120
SH Hake	07/17/2023 03:53	CTD	39.7791	-123.8766
SH Hake	07/17/2023 04:41	CTD	39.7774	-123.9639
SH Hake	07/17/2023 05:44	CTD	39.7764	-124.0718
SH Hake	07/17/2023 06:44	CTD	39.7775	-124.1145
SH Hake	07/25/2023 04:47	CTD	40.1097	-124.6081
SH Hake	07/25/2023 07:00	CTD	40.1096	-124.3879
SH Hake	07/25/2023 08:25	CTD	40.1144	-124.2942
SH Hake	07/25/2023 09:14	CTD	40.1134	-124.2841
SH Hake	07/25/2023 10:45	CTD	40.1148	-124.2011
SH Hake	07/26/2023 04:39	CTD	40.1127	-125.1708
SH Hake	07/26/2023 08:27	CTD	40.4465	-124.7096
SH Hake	07/26/2023 09:43	CTD	40.4468	-124.6175
SH Hake	07/26/2023 11:03	CTD	40.4465	-124.5227
SH Hake	07/27/2023 01:38	CTD	40.4462	-125.3127
SH Hake	07/27/2023 05:47	CTD	40.4466	-124.6289
SH Hake	07/27/2023 06:55	CTD	40.4451	-124.5992
SH Hake	07/28/2023 04:31	CTD	40.7788	-125.0280
SH Hake	07/28/2023 06:18	CTD	40.7800	-124.8131
SH Hake	07/28/2023 07:55	CTD	40.7791	-124.6441
SH Hake	07/28/2023 09:17	CTD	40.7792	-124.5350
SH Hake	07/28/2023 10:22	CTD	40.7789	-124.4906
SH Hake	07/28/2023 11:20	CTD	40.7796	-124.4505
SH Hake	07/28/2023 12:35	CTD	40.7782	-124.3119
SH Hake	07/29/2023 06:50	CTD	41.1127	-124.9017
SH Hake	07/29/2023 08:53	CTD	41.1130	-124.6293
SH Hake	07/29/2023 10:44	CTD	41.1122	-124.4178
SH Hake	07/30/2023 04:37	CTD	41.1112	-124.2395
SH Hake	07/30/2023 05:42	CTD	41.1110	-124.3332
SH Hake	07/30/2023 07:05	CTD	41.1138	-124.3807

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Vessel	Date Time	Cast Type	Latitude	Longitude
SH Hake	07/30/2023 08:21	CTD	41.1140	-124.5328
SH Hake	07/31/2023 05:20	CTD	41.4456	-125.0012
SH Hake	07/31/2023 07:31	CTD	41.4432	-124.7463
SH Hake	07/31/2023 09:35	CTD	41.4448	-124.5233
SH Hake	07/31/2023 10:51	CTD	41.4462	-124.4562
SH Hake	07/31/2023 11:32	CTD	41.4452	-124.5053
SH Hake	08/01/2023 04:49	CTD	41.7782	-125.0787
SH Hake	08/01/2023 07:09	CTD	41.7777	-124.7725
SH Hake	08/01/2023 09:07	CTD	41.7799	-124.5480
SH Hake	08/01/2023 10:18	CTD	41.7788	-124.4864
SH Hake	08/02/2023 04:35	CTD	42.1117	-124.4046
SH Hake	08/02/2023 05:38	CTD	42.1140	-124.5589
SH Hake	08/02/2023 06:32	CTD	42.1121	-124.6522
SH Hake	08/02/2023 07:48	CTD	42.1138	-124.7716
SH Hake	08/02/2023 09:02	CTD	42.1128	-124.8833
SH Hake	08/03/2023 05:16	CTD	42.4466	-124.9128
SH Hake	08/03/2023 06:41	CTD	42.4428	-124.8271
SH Hake	08/03/2023 07:58	CTD	42.4449	-124.7368
SH Hake	08/03/2023 08:30	CTD	42.4451	-124.7792
SH Hake	08/03/2023 11:16	CTD	42.7795	-124.7072
SH Hake	08/03/2023 11:53	CTD	42.7799	-124.7456
SH Hake	08/03/2023 13:05	CTD	42.7800	-124.8933
SH Hake	08/03/2023 14:36	CTD	42.7793	-125.0653
SH Hake	08/04/2023 04:29	CTD	43.1132	-125.0722
SH Hake	08/04/2023 05:36	CTD	43.1127	-125.0090
SH Hake	08/04/2023 07:01	CTD	43.1119	-124.8978
SH Hake	08/04/2023 09:50	CTD	43.1138	-124.5021
SH Hake	08/04/2023 10:51	CTD	43.1136	-124.6774
SH Hake	08/05/2023 04:28	CTD	43.4463	-124.5839
SH Hake	08/05/2023 05:20	CTD	43.4475	-124.6655
SH Hake	08/05/2023 06:22	CTD	43.4455	-124.7310
SH Hake	08/05/2023 08:10	CTD	43.4464	-124.9647
SH Hake	08/05/2023 09:50	CTD	43.4461	-125.1316
SH Hake	08/11/2023 06:09	CTD	43.7764	-124.2286
SH Hake	08/11/2023 07:44	CTD	43.7791	-124.5087
SH Hake	08/11/2023 08:43	CTD	43.7801	-124.6231
SH Hake	08/11/2023 09:52	CTD	43.7806	-124.7495
SH Hake	08/11/2023 11:41	CTD	43.7805	-124.9833
SH Hake	08/12/2023 03:16	CTD	44.1129	-124.1974
SH Hake	08/12/2023 03:31	CTD	44.1130	-124.1967
SH Hake	08/12/2023 06:50	CTD	44.1126	-124.9126
SH Hake	08/12/2023 07:39	CTD	44.1117	-124.9763
SH Hake	08/12/2023 08:16	CTD	43.9800	-124.9937
SH Hake	08/12/2023 09:38	CTD	44.1128	-125.1303
SH Hake	08/13/2023 05:33	CTD	44.4464	-125.2507
SH Hake	08/13/2023 07:51	CTD	44.4443	-125.0411
SH Hake	08/13/2023 09:28	CTD	44.4455	-124.9222

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Vessel	Date Time	Cast Type	Latitude	Longitude
SH Hake	08/13/2023 11:16	CTD	44.4462	-124.7394
SH Hake	08/14/2023 05:00	CTD	44.7789	-125.0161
SH Hake	08/14/2023 06:45	CTD	44.7769	-124.8550
SH Hake	08/14/2023 08:42	CTD	44.7802	-124.6100
SH Hake	08/14/2023 10:04	CTD	44.7786	-124.4529
SH Hake	08/14/2023 19:26	CTD	44.7818	-125.2920
SH Hake	08/15/2023 03:09	CTD	44.7808	-124.1558
SH Hake	08/15/2023 06:13	CTD	45.1121	-124.0471
SH Hake	08/15/2023 07:27	CTD	45.1123	-124.2255
SH Hake	08/15/2023 09:06	CTD	45.1124	-124.3757
SH Hake	08/16/2023 05:43	CTD	45.4452	-124.2295
SH Hake	08/16/2023 07:12	CTD	45.4465	-124.4536
SH Hake	08/16/2023 09:04	CTD	45.4451	-124.7287
SH Hake	08/16/2023 10:20	CTD	45.4453	-124.8477
SH Hake	08/16/2023 11:51	CTD	45.4455	-124.9881
SH Hake	08/17/2023 04:59	CTD	45.7800	-124.0264
SH Hake	08/17/2023 07:07	CTD	45.7803	-124.3740
SH Hake	08/17/2023 08:59	CTD	45.7791	-124.6922
SH Hake	08/17/2023 09:56	CTD	45.7784	-124.7799
SH Hake	08/17/2023 11:15	CTD	45.7800	-124.8982
SH Hake	08/18/2023 05:33	CTD	45.7773	-125.0979
SH Hake	08/18/2023 07:07	CTD	45.7768	-125.0184
SH Hake	08/19/2023 04:03	CTD	46.1122	-124.9831
SH Hake	08/19/2023 05:57	CTD	46.1131	-125.1520
SH Hake	08/19/2023 08:07	CTD	46.1135	-124.8625
SH Hake	08/19/2023 09:32	CTD	46.1118	-124.7426
SH Hake	08/19/2023 11:10	CTD	46.1127	-124.5818
SH Hake	08/20/2023 03:39	CTD	46.4442	-124.2501
SH Hake	08/20/2023 05:21	CTD	46.4448	-124.5164
SH Hake	08/20/2023 06:02	CTD	46.4456	-124.5473
SH Hake	08/20/2023 07:11	CTD	46.4462	-124.5746
SH Hake	08/20/2023 08:32	CTD	46.4457	-124.6933
SH Hake	08/20/2023 09:54	CTD	46.4469	-124.8172
SH Hake	08/20/2023 11:27	CTD	46.4454	-124.9677
SH Hake	08/21/2023 04:11	CTD	46.7781	-125.3161
SH Hake	08/21/2023 05:51	CTD	46.7779	-125.1461
SH Hake	08/21/2023 07:35	CTD	46.7800	-125.0270
SH Hake	08/21/2023 08:58	CTD	46.7806	-124.9060
SH Hake	08/21/2023 10:01	CTD	46.7792	-124.8657
SH Hake	08/21/2023 11:18	CTD	46.7796	-124.7364
SH Hake	08/21/2023 13:38	CTD	46.7784	-124.2930
SH Hake	08/22/2023 04:50	CTD	47.1134	-125.1473
SH Hake	08/22/2023 06:07	CTD	47.1114	-124.9996
SH Hake	08/22/2023 07:05	CTD	47.1122	-124.9827
SH Hake	08/22/2023 07:59	CTD	47.1121	-124.9076

C Trawl sample summary

Date, time, and location at the start of trawling (i.e., at net equilibrium, when the net is fully deployed and begins fishing), and biomasses (kg) of CPS collected for each trawl haul aboard *Lasker* and *Shimada*.

Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
1	07/18/2023 01:40	32.9867	-117.3315	0.00	2.71			0.05	2.76
2	07/18/2023 20:46	32.4228	-117.4888	0.01	0.99			0.05	1.06
3	07/18/2023 23:00	32.5275	-117.5548	0.02	2.15			0.09	2.26
4	07/19/2023 02:05	32.4957	-117.5010	0.06	1.65			0.01	1.71
5	07/19/2023 21:42	32.6797	-118.3587	5.47				0.11	5.58
6	07/20/2023 00:26	32.7597	-118.5702	1.25				0.25	1.50
7	07/20/2023 02:54	32.7063	-118.8107	0.01					0.01
8	07/20/2023 20:57	33.4115	-117.7143	0.07	7.55		0.01	0.10	7.74
9	07/20/2023 23:47	33.3842	-117.9362	0.36	1.57			0.14	2.06
10	07/21/2023 02:34	33.2145	-118.1317	0.11			0.37	2.81	3.29
11	07/21/2023 22:38	33.5525	-118.0923		6.23			0.03	6.26
12	07/22/2023 02:36	33.4757	-118.4990	3.36				2.21	5.58
13	07/22/2023 22:39	33.7572	-119.3412		0.01				0.01
14	07/23/2023 02:07	33.4592	-119.2437	0.04	53.73				53.77
15	07/23/2023 21:45	33.1205	-119.1608	0.02					0.02
16	07/24/2023 01:42	32.8563	-119.5537	0.01	0.57				0.58
17	07/24/2023 03:40	32.9470	-119.6165	0.01	0.07				0.07
18	07/24/2023 20:42	33.6022	-120.4332						
19	07/24/2023 23:41	33.5813	-120.2883						
20	07/25/2023 02:38	33.4553	-120.3525	0.01					0.01
21	07/25/2023 20:40	34.0997	-120.9907		0.61				0.61
22	07/25/2023 23:33	34.0593	-120.8387	0.01					0.01
23	07/26/2023 01:55	34.1863	-120.8292		3.12				3.12
24	07/26/2023 21:35	34.0232	-119.4870	0.12	0.02				0.14
25	07/27/2023 02:55	34.1420	-119.3730	0.01	0.10				0.12
26	07/27/2023 22:23	34.6387	-120.7038		7.66			1.97	9.63
27	07/28/2023 00:52	34.5802	-120.8102						
28	07/28/2023 03:29	34.5045	-120.7717						
29	07/28/2023 20:37	34.8677	-121.0053		177.79				177.79
30	07/28/2023 23:17	34.9340	-120.8670		293.18				293.18

(continued)

Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
31	07/29/2023 02:57	35.0383	-120.8493		6.55				6.55
32	09/07/2023 00:01	34.7460	-121.3628	3.82					3.82
33	09/07/2023 02:46	34.6558	-121.4165	0.01					0.01
34	09/07/2023 21:28	35.4517	-121.5067	0.01	63.53				63.54
35	09/08/2023 00:16	35.4575	-121.2102		0.25				0.25
36	09/08/2023 02:54	35.5625	-121.1850		297.69				297.69
37	09/08/2023 19:54	35.6597	-121.8638	0.18	53.52				53.70
38	09/09/2023 00:00	35.8265	-121.4312		0.00				0.00
39	09/09/2023 03:22	36.0280	-121.8118	0.00	0.01				0.02
40	09/09/2023 22:21	36.2720	-122.1122	0.59	1.26				1.86
41	09/10/2023 03:13	36.7552	-121.9413		103.17			0.04	103.21
42	09/10/2023 19:55	37.0990	-122.7038		612.83			0.17	613.00
43	09/10/2023 23:43	37.0630	-122.9053		61.47				61.47
44	09/11/2023 02:43	37.0050	-123.0512	0.01					0.01
45	09/11/2023 20:15	37.3877	-123.0442		0.19				0.19
46	09/11/2023 23:57	37.6930	-123.2240		5.46				5.46
47	09/12/2023 02:42	37.5938	-123.4230		0.49				0.49
48	09/15/2023 23:19	38.0478	-123.3868		9.82				9.82
49	09/16/2023 03:30	38.3907	-123.3952	0.01	0.13				0.14
50	09/16/2023 20:47	39.0013	-123.7905	0.01	179.93				179.94
51	09/16/2023 23:25	38.9522	-123.9003		1322.29				1322.29
52	09/17/2023 19:52	39.7130	-124.0060	4.81	12.36				17.17
53	09/22/2023 21:59	40.4757	-124.6075	0.13	1.59				1.72
54	09/23/2023 00:33	40.2573	-124.5187	35.99					35.99
55	10/13/2023 01:03	44.4438	-124.6258	0.57					0.57
56	10/13/2023 04:27	44.4475	-124.4105	0.01		0.28		77.39	77.68
57	10/13/2023 22:23	44.7955	-124.1357		0.07	0.25		0.01	0.33
58	10/14/2023 01:06	44.7833	-124.2857						
59	10/14/2023 18:52	45.4450	-124.2548	0.01		2.74		0.09	2.84
60	10/14/2023 21:42	45.4580	-124.0717	0.04	0.15	1.11		0.31	1.62
61	10/15/2023 01:30	45.6325	-124.0650	0.02	0.07	0.27	0.02	2.67	3.04
62	10/15/2023 18:50	46.1100	-124.2612	0.03	0.03	2.40		0.24	2.71
63	10/15/2023 21:17	46.1208	-124.4560	0.35					0.35

(continued)

Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
64	10/15/2023 23:53	46.1168	-124.7107	0.01					0.01
65	10/26/2023 20:15	44.1183	-124.4118	0.08		0.85			0.93
66	10/26/2023 23:17	44.1132	-124.2317	0.00	0.01	0.20		0.01	0.21
67	10/27/2023 01:59	43.9745	-124.2560	0.04		1.64	0.47	1.05	3.19
68	10/28/2023 00:15	46.3622	-124.9182	0.00					0.00
69	10/28/2023 02:57	46.4345	-124.5590	0.02		0.19			0.21
70	10/28/2023 18:12	46.7597	-124.3587		222.22	3.30			225.53
71	10/28/2023 21:33	46.7598	-124.5005	0.00	8.20	0.27		2.85	11.33
72	10/29/2023 00:25	46.9312	-124.6047	0.03	0.84	0.60		0.52	1.99
73	10/30/2023 18:46	47.1052	-124.5037	0.01				0.22	0.23
74	10/29/2023 21:40	47.1073	-124.6820			1.50		0.48	1.97
75	10/30/2023 00:40	47.1100	-124.9202			0.05			0.05
76	10/30/2023 19:07	47.4508	-124.6242	0.00	0.10	2.51		1.71	4.33
77	10/30/2023 23:15	47.6228	-124.7527	0.00		0.94		0.45	1.40
78	10/31/2023 02:27	47.7973	-124.8038			1.35			1.35
79	10/31/2023 18:38	48.1132	-124.9798			51.62		0.41	52.03
80	10/31/2023 21:13	48.1288	-125.1450	1.69		26.52		2.21	30.42
81	11/01/2023 01:03	48.1445	-125.6153			0.32		0.34	0.66

D Seine sample summary

D.1 *Lisa Marie*

Date, time (UTC), location, and biomasses (kg) of CPS collected for each purse seine set by *Lisa Marie*.

Set	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
1	08/11/2023 00:42	38.3150	-123.1743		7.61				7.61
2	08/11/2023 16:49	38.5916	-123.4178						
3	08/13/2023 12:34	39.5406	-123.8910		2.97				2.97
4	08/13/2023 18:33	39.8741	-124.0087	24.21			0.39		24.59
5	08/14/2023 13:56	40.1292	-124.3161	11.42					11.42
6	08/14/2023 21:28	40.5052	-124.4326						
7	08/15/2023 16:50	40.7899	-124.2611			1.53			1.53
8	08/16/2023 16:39	40.9567	-124.2510						
9	08/16/2023 17:30	40.9552	-124.1837			0.12			0.12
10	08/16/2023 21:50	41.2560	-124.2020	17.80					17.80
11	08/17/2023 15:50	41.6151	-124.1682						
12	08/17/2023 20:00	41.8581	-124.2859			0.34			0.34
13	08/22/2023 15:42	42.2814	-124.4270			2.08			2.08
14	08/22/2023 19:55	42.6191	-124.4259						
15	08/23/2023 17:38	43.2294	-124.5770						
16	08/24/2023 18:44	43.9416	-124.2377						
17	08/24/2023 20:59	44.1040	-124.2689					5.82	5.82
18	08/24/2023 22:17	44.1064	-124.3717						
19	08/24/2023 23:41	44.1076	-124.4916					12.88	12.88
20	08/25/2023 04:36	44.0884	-124.9284	4.99			3.77	2.15	10.92
21	08/25/2023 06:52	44.0981	-124.6396	4.64				10.55	15.20
22	08/26/2023 04:19	44.7728	-124.4771	11.48		1.05		0.28	12.82
23	08/26/2023 16:48	45.1051	-124.0089			2.25			2.25
24	08/27/2023 03:47	45.4600	-124.3865	5.48				4.40	9.88
25	08/27/2023 05:35	45.6034	-124.3361	4.11		0.46	2.45	8.98	15.99
26	08/27/2023 06:42	45.6020	-124.2275	1.18		8.89			10.07
27	08/27/2023 20:43	45.8934	-123.9979						
28	08/27/2023 23:34	45.9360	-124.3064						
29	08/28/2023 04:20	45.9871	-124.7258	11.63				1.04	12.67

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Set	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
30	08/28/2023 05:51	46.1048	-124.6191	2.98				7.66	10.64
31	08/28/2023 07:57	46.1047	-124.3170		0.03	0.05			0.08
32	08/28/2023 22:54	46.3931	-124.0921		0.04	8.71			8.75
33	08/29/2023 01:10	46.4525	-124.2751	7.19				3.51	10.70
34	08/29/2023 04:00	46.4422	-124.4472					3.53	3.53
35	08/29/2023 05:51	46.6087	-124.5113	4.06	0.04	0.99		2.52	7.62
36	08/29/2023 07:20	46.6147	-124.3595			0.74		15.19	15.93
37	08/29/2023 20:40	46.7774	-124.3603						
38	08/30/2023 04:45	46.9441	-124.7416	14.68				0.19	14.87
39	08/30/2023 06:35	47.1132	-124.7452					11.41	11.41
40	08/30/2023 08:13	47.1096	-124.5573			0.20		0.50	0.71
41	08/31/2023 03:49	47.2839	-124.7443	3.11		0.24		0.26	3.61
42	08/31/2023 05:06	47.3524	-124.7256			18.16		0.60	18.77
43	08/31/2023 18:40	47.6131	-124.4347			2.53			2.53
44	08/31/2023 21:46	47.7808	-124.6893						
45	09/01/2023 04:33	47.8038	-125.0821					11.70	11.70
46	09/01/2023 06:27	47.9443	-125.1874	9.13		3.31		0.22	12.66
47	09/01/2023 07:43	47.9449	-125.0258	8.76		9.59		0.50	18.84
48	09/01/2023 18:40	47.9909	-124.8154	4.57					4.57
49	09/02/2023 05:21	48.0156	-125.0835			8.48			8.48
50	09/02/2023 06:59	47.9631	-124.8703	21.83		5.60			27.43
51	09/02/2023 07:58	47.9528	-124.7989					16.18	16.18
52	09/02/2023 09:16	47.9841	-124.8212					12.16	12.16

D.2 *Long Beach Carnage*

Date, time (UTC), location, and biomasses (kg) of CPS collected for each purse seine set by *Long Beach Carnage*.

Set	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
1	07/08/2023 15:25	32.5566	-117.1854					31.30	31.30
2	07/08/2023 19:10	32.6306	-117.1582					24.49	24.49
3	07/09/2023 00:14	32.7790	-117.2695					23.59	23.59
4	07/09/2023 03:14	32.8638	-117.2658					29.94	29.94
5	07/10/2023 01:44	33.2688	-117.4843				0.91	19.96	20.87
6	07/09/2023 14:40	32.9532	-117.2822					25.40	25.40
7	07/09/2023 17:08	33.0348	-117.3105				0.45	19.50	19.96
8	07/09/2023 19:45	33.1413	-117.3585					31.30	31.30
9	07/09/2023 22:14	33.1818	-117.4047				7.71	1.81	9.53
10	07/10/2023 00:59	33.2515	-117.4657					26.76	26.76
11	07/10/2023 16:05	33.3400	-117.5460					27.67	27.67
12	07/10/2023 18:45	33.5485	-117.6295					23.13	23.13
13	07/10/2023 21:14	33.4387	-117.6622		18.14				18.14
14	07/11/2023 01:34	33.5595	-117.8298					24.04	24.04
15	07/11/2023 06:25	33.3712	-118.3327					23.59	23.59
16	07/12/2023 04:37	33.3528	-118.3190					20.87	20.87
17	07/12/2023 05:12	33.3575	-118.3222				6.80	20.87	27.67
18	07/12/2023 06:56	33.4043	-118.3483					4.54	4.54
19	07/12/2023 20:30	33.6137	-117.9575					28.12	28.12
20	07/12/2023 22:17	33.6333	-118.0167						
21	07/13/2023 01:00	33.7352	-118.1583		23.13			4.54	27.67
22	07/13/2023 17:30	33.7008	-118.2955				11.79	4.08	15.88
23	07/13/2023 23:01	33.8473	-118.4245				1.81	23.59	25.40
24	07/14/2023 01:21	33.9253	-118.4555				10.43	16.33	26.76
25	07/14/2023 03:50	33.9910	-118.5138		19.05			4.54	23.59
26	07/14/2023 15:46	34.0142	-118.8372					1.36	1.36
27	07/14/2023 16:27	34.0148	-118.8357					32.66	32.66
28	07/14/2023 18:05	33.9715	-118.9197		12.70				12.70
29	07/15/2023 18:05	33.9983	-119.6278					23.59	23.59
30	07/16/2023 01:06	33.9830	-119.6558				24.95		24.95
31	07/16/2023 02:12	33.9747	-119.6787				27.22		27.22

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Set	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	All CPS
32	07/16/2023 03:33	33.9580	-119.7327				0.91	28.58	29.48
33	07/16/2023 19:20	34.0685	-119.8438						
34	07/16/2023 23:59	34.0295	-119.6127						
35	07/17/2023 03:23	34.0298	-119.6127					25.40	25.40
36	07/17/2023 15:50	34.2572	-119.3153		17.24				17.24
37	07/17/2023 20:04	34.3572	-119.5437				9.07		9.07
38	07/17/2023 22:55	34.4053	-119.7763				1.36	27.67	29.03
39	07/18/2023 01:09	34.4163	-119.9187					29.48	29.48
40	07/18/2023 18:11	34.4097	-120.2005					24.04	24.04
41	08/08/2023 01:34	35.0947	-120.6528					30.39	30.39
42	08/08/2023 02:14	35.0945	-120.6542		19.96				19.96
43	08/08/2023 20:30	35.3248	-120.8842					23.13	23.13
44	08/09/2023 20:23	35.5883	-121.1423		17.24				17.24
45	08/10/2023 01:32	35.6205	-121.1993		4.99			29.48	34.47
46	08/10/2023 02:45	35.6275	-121.1807		12.25				12.25
47	08/10/2023 16:35	35.7808	-121.3593					24.04	24.04
48	08/10/2023 17:52	35.8197	-121.3957						
49	08/11/2023 02:34	36.0088	-121.5445		17.69				17.69
50	08/12/2023 23:21	36.8267	-121.8073					6.35	6.35
51	08/13/2023 02:37	36.9020	-121.8512		3.18		0.45	26.76	30.39
52	08/13/2023 15:44	36.9442	-122.0760		19.05				19.05
53	08/13/2023 20:41	37.0697	-122.2760		16.78			0.45	17.24
54	08/14/2023 00:55	37.1395	-122.3682		14.51				14.51
55	08/15/2023 17:26	37.7267	-122.6162		23.59				23.59
56	08/15/2023 23:48	37.9262	-122.7757		19.50				19.50