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REPORT ON THE SUMMER 2021 CALIFORNIA CURRENT ECOSYSTEM SURVEY (CCES) (2107RL), 6 JULY TO 15 OCTOBER 2021, CONDUCTED ABOARD NOAA SHIP *REUBEN LASKER*, MEXICAN RESEARCH VESSEL *DR. JORGE CARRANZA FRASER*, FISHING VESSELS *LISA MARIE* AND *LONG BEACH CARNAGE*, AND UNCREWED SURFACE VEHICLES

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Report on the Summer 2021 California Current Ecosystem Survey (CCES) (2107RL), 6 July to 15 October 2021, conducted aboard NOAA ship *Reuben Lasker*, Mexican research vessel *Dr. Jorge Carranza Fraser*, fishing vessels *Lisa Marie* and *Long Beach Carnage*, and uncrewed surface vehicles

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1 Introduction

The Summer 2021 California Current Ecosystem Survey (CCES) (2107RL) was conducted by the Fisheries Resources Division (FRD) of the Southwest Fisheries Science Center (SWFSC) aboard NOAA ship *Reuben Lasker* (hereafter *Lasker*) (**Fig.** 1), 6 July to 15 October 2021, and augmented by data collected from the Mexican research vessel *Dr. Jorge Carranza Fraser* (hereafter *Carranza*), fishing vessels *Lisa Marie* and *Long Beach Carnage*, and uncrewed surface vehicles (USVs; Saildrone, Inc.). The Acoustic-Trawl Method (ATM) is routinely used to assess coastal pelagic fish species (CPS) and krill within the California Current Ecosystem (CCE), between Vancouver Island, British Columbia and San Diego, CA. In 2021, for the first time, the survey extended southward to central Baja California, Mexico. Data were collected using multi-frequency echosounders, surface trawls, 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 of CPS, e.g., Pacific Sardine *Sardinops sagax*, Northern Anchovy *Engraulis mordax*, Pacific Herring *Clupea pallasii*, Pacific Round Herring *Etrumeus acuminatus*, Pacific Mackerel *Scomber japonicus*, and Jack Mackerel *Trachurus symmetricus*; and krill (euphausiid spp.); 2) characterize and investigate linkages to their biotic and abiotic environments; 3) gather information regarding their life histories; and 4) use fishing vessels and USVs to sample in offshore and nearshore areas when and where sampling from NOAA ships was deemed inefficient, unsafe, or both (**Fig.** 1).

The survey domain, from Cape Flattery, WA to Central Baja California, Mexico, was defined primarily by the modeled distribution of potential habitat for 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 distributions 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 it also spanned portions of the southern stock of Pacific Sardine, Pacific Mackerel, Jack Mackerel, Pacific Round Herring, and Pacific Herring.

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.

This survey was conducted with the approval of the Secretaria de Relaciones Exteriores (SRE, Diplomatic note CTC/1312/2021), the Instituto Nacional de Estadística y Geografía (INEGI; Permit: EG0082021), and the Comisión Nacional de Acuacultura y Pesca (CONAPESCA; Permit: PPFE/DGOPA-073/21).

Figure 1: NOAA ship *Lasker* (top left), RV *Dr. Jorge Carranza Fraser* (bottom left), F/V *Long Beach Carnage* (top right), F/V *Lisa Marie* (middle right), and an uncrewed surface vehicle (Saildrone USV, bottom right).

1.1 Scientific Personnel

The collection and analysis of the survey data were conducted by members of 1-NOAA, 2-INAPESCA, 3-Maz Sardina, and 4-volunteers. Asterisks denote Chief Scientists.

Project Lead:

- D. Demer

Acoustic Data Collection and Processing:

- *Lasker*
  - Leg I: J. Renfree[1*] and G. Johnson[1]
  - Leg II: S. Mau[1], E. Pérez-Flores[2], and S. Dolan[4]
  - Leg III: J. Zwolinski[1*], D. Murfin[1], and L. Altamirano-López[2]
  - Leg IV: K. Stierhoff[1*], S. Sessions[1], and R. Vallarta-Zárate[2]
- *Carranza*
  - M. Vásquez-Ortiz[2] and L. Altamirano-López[2]

Trawl Sampling:

- *Lasker*
  - Leg I: M. Craig[1], L. Heberer[1], P. Kuriyama[1], and S. Hensman[4]
  - Leg II: B. Schwartzkopf[1], L. Martin[1], B. Bellerud[1], J. Barnes[4], and D. Hernández-Cruz[2]
  - Leg III: O. Snodgrass[1], E. Adams[1], C. Fahy[1], Z. Skelton[1], and J. Walker[1]
  - Leg IV: K. James[1], K. Koch[1], K. Lane[1], D. Lowry[1], and J. Osuna-Soto[3]
- *Carranza*
  - D. Hernández-Cruz[2], L. Huidobro-Campos[2], A. Lizárraga-Rodríguez[2], and S. Padilla-Galindo[2]

CUFES Sampling:

- *Lasker*
  - Leg I: E. Gardner[1] and A. Freire de Carvalho[1]
  - Leg II: W. Watson[1*] and M. Human[1]
  - Leg III: E. Gardner[1] and S. Morales-Gutiérrez[2]
  - Leg IV: L. Vasquez[1] and V. Martínez-Magaña[2]
- *Carranza*
  - S. Gutiérrez[2]

Purse-seine Sampling:

- *Lisa Marie*
  - K. Hinton and P. Biondo
- *Long Beach Carnage*
  - K. Kloos, T. Nguyen, J. van Noord, and T. Stocking

Echosounder Calibrations:

- *Lasker*
  - D. Demer[1], D. Murfin[1], J. Renfree[1], and S. Dolan[4]
- *Lisa Marie*
  - J. Renfree[1]
- *Long Beach Carnage*
  - D. Murfin[1] and J. Renfree[1]
- *Saildrone*
  - Saildrone, Inc. and J. Renfree[1]
- *Carranza*
  - M. Vásquez-Ortiz[2], L. Altamirano-López[2], and S. Padilla-Galindo[2]

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 spring, the northern stock of Pacific Sardine typically aggregates offshore of central and southern California to spawn (Demer *et al.*, 2012, and reference therein). During summer, if the stock is large enough, adults migrate north, compress along the coast, and feed in the upwelled regions (**Fig. 2**). Since approximately 2012, however, the seasonal migration of the northern stock of Pacific Sardine diminished to the extent that it remains north of Cape Mendocino year-round.

During summer 2021, the west coasts of the United States and Baja California were surveyed using *Lasker*, *Carranza*, *Lisa Marie*, *Long Beach Carnage*, and USVs. Compulsory transects were nearly perpendicular to the coast and separated by 10 nmi. The survey began off Cape Flattery, WA and the combination of survey platforms progressed southwards toward Punta Abreojos, MX.

The planned transects (**Fig. 3**) spanned the latitudinal extent of the potential habitat of the northern stock of Pacific Sardine[1] at the time of the survey (**Fig. 4**). For *Lasker*, the planned transects ranged from Vancouver Island, British Columbia to Punta Eugenia, MX. Due to time constraints, Vancouver Island was omitted, and *Lasker*'s southernmost transect ended at Las Flores, MX. The offshore extent of the planned transects was adjusted during the survey according to the observed distribution of putative CPS backscatter in the echograms, CPS eggs in the CUFES samples, or CPS caught in trawls. To survey farther south into Baja California, *Carranza* planned to sample from Punta Eugenia to Punta Abreojos, MX, but began the former at Las Flores, MX to begin sampling where *Lasker* concluded. To increase the spatial sampling resolution from *Lasker*, acoustic sampling was conducted by USVs interstitial to *Lasker* transects from Cape Flattery, WA to Crescent City, CA (SD-1055 and SD-1059) and Point Arena to Point Conception, CA (SD-1036, SD-1055, and SD-1059). USVs (SD-1036 and SD-1059) were additionally used to sample the offshore extents of *Lasker* transects in the Southern California Bight. To estimate CPS biomass near shore, where it is too shallow to navigate NOAA ships safely, sampling from *Lasker* was augmented with echosounder and purse-seine sampling from *Lisa Marie* between Cape Flattery, WA to Bodega Bay, CA; and *Long Beach Carnage* from Bodega Bay, CA to the US/Mexico border, and around Santa Cruz and Santa Catalina Islands (**Fig. 3**).

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

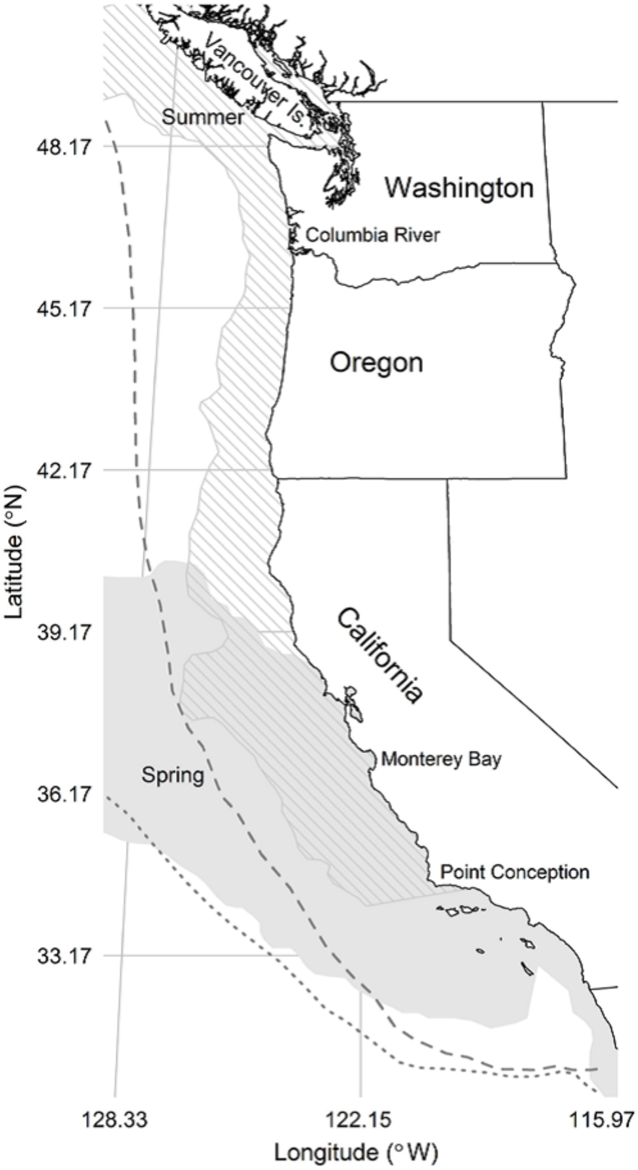

Figure 2: Conceptual spring (shaded region) and summer (hashed region) distributions of potential habitat for the northern stock of Pacific Sardine along the west coasts of Mexico, the United States, and Canada. The dashed and dotted lines represent, respectively, the approximate summer and spring positions 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.

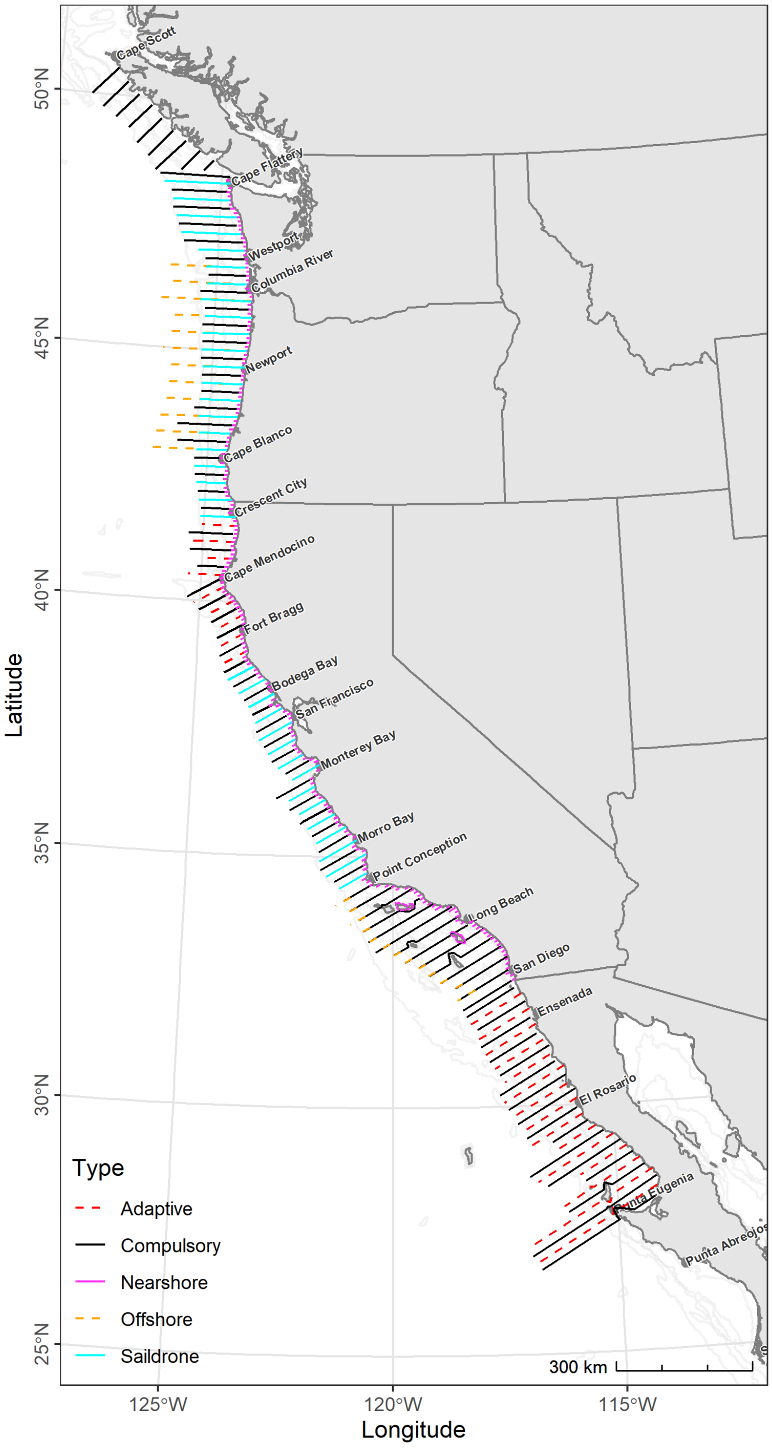

Figure 3: Planned core-area (solid black lines) and adaptive (dashed red lines) transect lines sampled by *Lasker* and *Carranza*; optional offshore transect extensions for potential sampling by *Lasker* (dashed orange lines); interstitial transects sampled by USVs (solid cyan lines); and nearshore transect lines sampled by fishing vessels (solid magenta lines). Isobaths (light gray lines) are placed at 50, 200, 500, and 2,000 m (or approximately 25, 100, 250, and 1,000 fathoms).

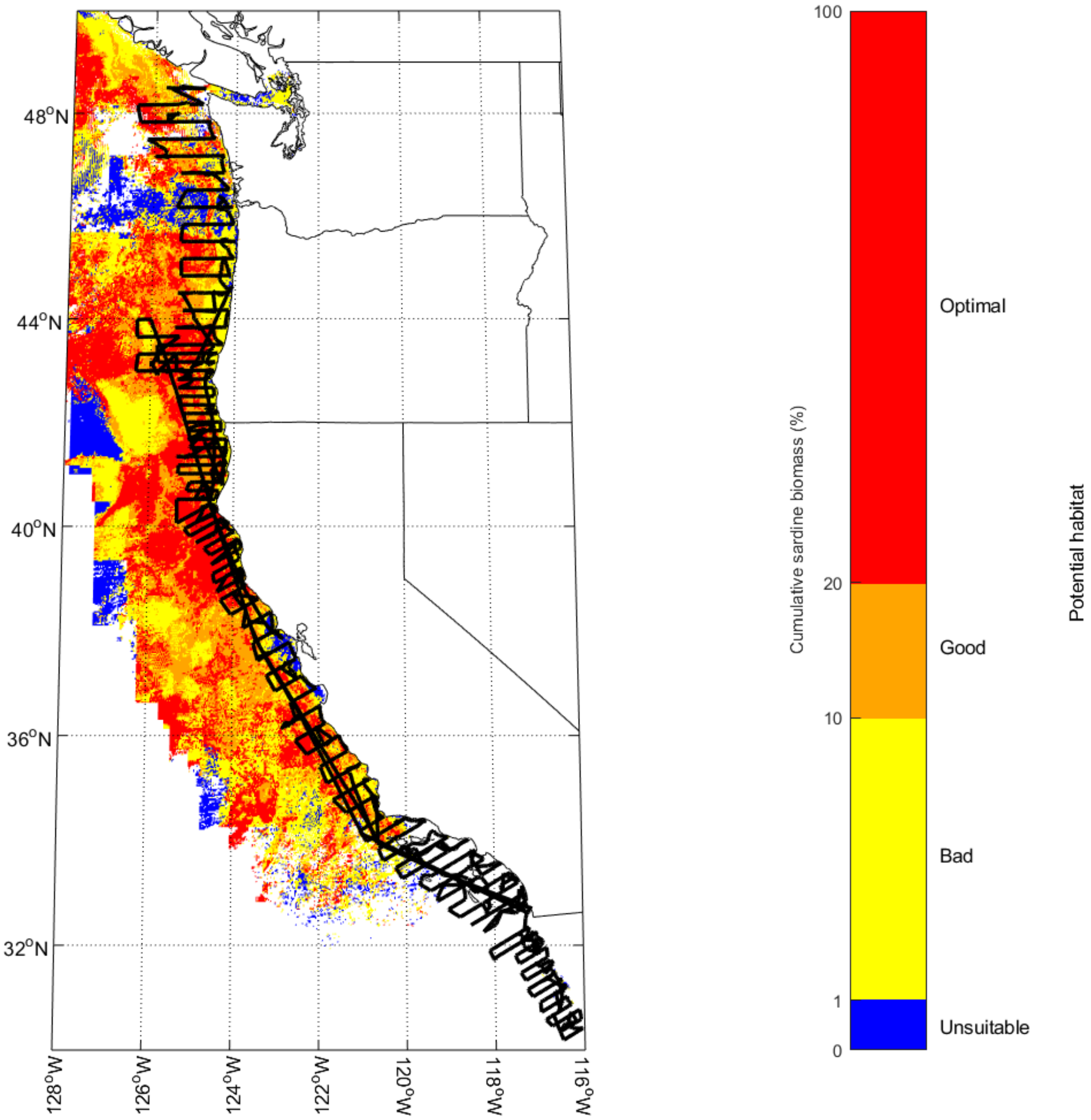

Figure 4: Distribution of potential habitat for the northern stock of Pacific Sardine, temporally aggregated using an average of the habitat centered ±2° around *Lasker* positions throughout the survey. Areas in white correspond to no available data, e.g., cloud coverage preventing satellite-sensed observations.

2.2 Acoustic sampling

2.2.1 Echosounders

On *Lasker*, multi-frequency Wideband Transceivers (18-, 38-, 70-, 120-, 200-, and 333-kHz Simrad EK80 WBTs) were configured with split-beam transducers (Simrad ES18-11, ES38B, ES70-7C, ES120-7C, ES200-7C, and ES333-7C). The transducers were mounted on the bottom of a retractable keel or "centerboard" (**Fig. 5**). 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 (POS-MV; Trimble/Applanix).

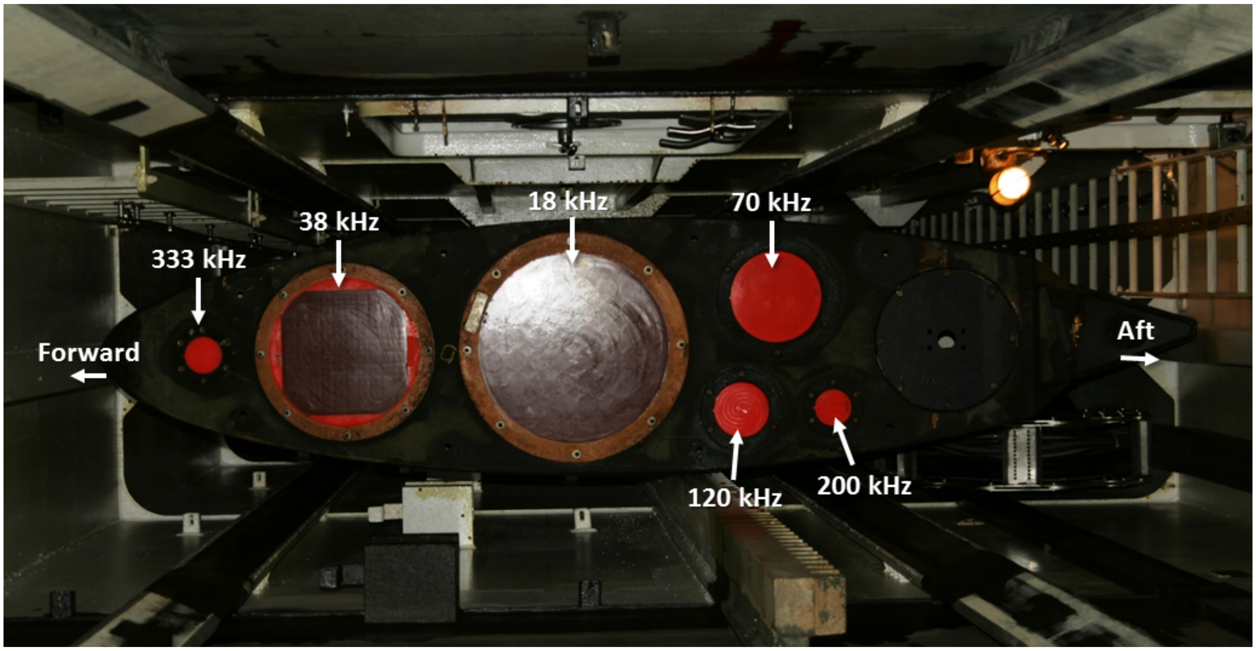

Figure 5: Transducer locations on the bottom of the centerboard aboard *Lasker*.

On *Carranza*, multi-frequency General Purpose Transceivers (18-, 38-, 70-, 120-, and 200-kHz Simrad EK60 GPTs) were configured with split-beam transducers (Simrad ES18, ES38B, ES70-7C, ES120-7C, and ES200-7C) mounted on the bottom of a retractable keel, placing them approximately 4 m beneath the water surface.

On *Lisa Marie*, the SWFSC's General Purpose Transceiver (38-kHz Simrad EK60 GPT) was connected to the vessel's hull-mounted split-beam transducer (Simrad ES38B).

On *Long Beach Carnage*, the SWFSC's multi-frequency General Purpose Transceivers (38-, 70-, 120-, and 200-kHz Simrad EK60 GPTs) were configured with the SWFSC's split-beam transducers (Simrad ES38-12, ES70-7C, ES120-7C and ES200-7C) mounted in a multi-frequency transducer array (MTA4) on the bottom of a pole (**Fig. 6**).

On the three USVs (SD-1036, SD-1055, and SD-1059), miniature Wideband Transceivers (Simrad WBT Mini) were configured with gimbaled, keel-mounted, dual-frequency transducers (Simrad ES38-18|200-18C) containing a split-beam 38-kHz transducer and single-beam 200-kHz transducer with nominally 18° beamwidths.

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

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 (i.e., continuous wave or chirp mode) and FM modes (i.e., 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; *Lasker* sphere #1); For FM mode, additional calibrations were conducted for the 120, 200, and 333-kHz echosounders using a smaller 25-mm WC sphere. On *Carranza*, the EK60 GPTs were calibrated using a WC38.1, except for the 18-kHz GPT that was calibrated using a 63-mm diameter copper sphere (Cu63). Calibrations for *Lisa Marie*, *Long Beach Carnage*, and the USVs were all conducted using a WC38.1. On each vessel, the GPTs or WBTs were configured using the calibration results via the control software (EK80 v2.0.0, Simrad; see **Section 3.1**).

2.2.3 Data collection

On *Lasker*, the computer clocks were synchronized with the GPS clock (UTC) using synchronization software (NetTime[2]). The 18-kHz WBT, operated by a separate PC from the other echosounders, was programmed

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[2] http://timesynctool.com

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[3], 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 logged to 60 m beyond the detected seabed range or to a maximum range of 1000, 1000, 700, 300, and 150 m for 38, 70, 120, 200, and 333 kHz, respectively, and stored in Simrad .raw format with a 1-GB maximum file size. During daytime and nighttime, the echosounders were set to operate in CW and FM modes, respectively. For each acoustic instrument, the prefix for each file name is a concatenation of the survey name (e.g., 2107RL), the operational mode (CW or FM), and the logging commencement date and time from the EK80 software. For example, a file generated by the Simrad EK80 software (v2.0.0) for a WBT operated in CW mode is named `2107RL-CW-D20210723-T125901.raw`.

To minimize acoustic interference, transmit pulses from the EK80s, acoustic Doppler current profiler and echosounder (Simrad EC150-3C), multibeam echosounder (Simrad ME70), imaging sonar (Simrad MS70), scanning sonar (Simrad SX90), and a separate acoustic Doppler current profiler (Teledyne RD Instruments OS75 ADCP) were triggered using a synchronization system (Simrad K-Sync). The K-Sync trigger rate, and thus the echosounder ping interval, was modulated by the EAL using the 18-kHz seabed depth provided by *Lasker*'s Scientific Computing System (SCS). During daytime, the EC150-3C, ME70, SX90, and ADCP were operated continuously, while the MS70 was only operated at times when CPS were present. At nighttime, only the EK80, EC150-3C, and ADCP were operated. All other instruments that can produce 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 *Carranza*, the EK60 echosounders were triggered using a synchronization system (Simrad K-Sync). During daytime acoustic transects, no other acoustic sounders were operated. The ping interval and recording range were modulated based on the seabed depth, respectively: 0.25 s and 100 m for a depth of 0-50 m; 0.5 s and 150 m for a depth of 50-100 m; 0.75 s and 200 m for a depth of 100-150 m; 1 s and 300 m for a depth of 150-200 m; and 2 s and 500 m for a depth of 250-500 m.

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 200 and 500 m, respectively, and used the maximum ping rate. Transmit pulses from the EK60s 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.

2.2.4 Data processing

Echoes from schooling CPS and plankton (**Figs. 7a, d**) were identified using a semi-automated data processing algorithm implemented using Echoview software (v12; Echoview Software Pty Ltd). The filters and thresholds were based on a subsample of echoes from randomly selected CPS schools. The aim of the

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[3] https://www.fisheries.noaa.gov/west-coast/science-data/ek80-adaptive-logger/

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*, *Carranza*, 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. Compute the 120- and 200-kHz Variance-to-Mean Ratios ($VMR_{120\text{kHz}}$ and $VMR_{200\text{kHz}}$, respectively, Demer *et al.*, 2009) using the difference between noise-filtered S_v (Step 3) and averaged S_v (Step 4);
9. Expand the $VMR_{120\text{kHz}}$ and $VMR_{200\text{kHz}}$ echograms with a 7 pixel x 7 pixel dilation;
10. Create a Boolean echogram based on the VMRs in the CPS range: $VMR_{120\text{kHz}} >$ -65 dB and $VMR_{200\text{kHz}} >$ -65 dB. Diffuse backscattering layers have low VMR (Zwolinski *et al.*, 2010) whereas fish schools have high VMR (Demer *et al.*, 2009);
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., 1000 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 *Lisa Marie* were processed using the following steps:

1. Remove shorter-duration, transient noise (e.g., ship's asynchronous sonar) using the Impulse Noise Removal operator;
2. Remove longer-duration, transient noise (e.g., wave-hull collisions) using the Transient Noise Removal operator;
3. Compensate attenuated signals (e.g., from air-bubble attenuation) using the Attenuated Signal Removal operator;
4. Average the noise-free 38-kHz S_v echograms using non-overlapping 11-sample by 3-ping bins;
5. Compute the VMR using the difference between noise-filtered S_v (Step 3) and averaged S_v (Step 4);
6. Create a Boolean echogram mask using $VMR >$ -48 dB;
7. Expand the Boolean mask with a 7 pixel x 7 pixel dilation;
8. Performs Steps 12-17 from *Lasker* processing.

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: $-13.5 < S_{v,200\text{kHz}} - S_{v,38\text{kHz}} < 9.37$

6. Perform Steps 8-9 from *Lasker* processing;
7. Create a Boolean echogram mask using $VMR >$ -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 schools were further excluded.

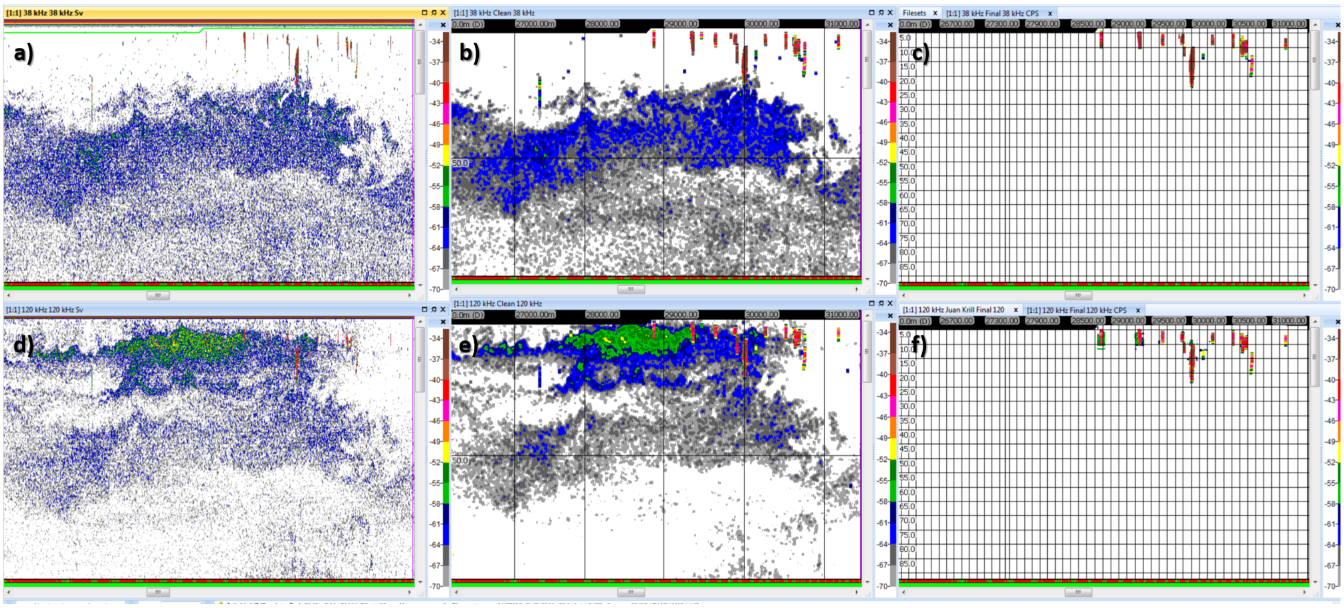

Figure 7: Echogram depicting CPS schools (red) and plankton aggregations (blue and green) at 38 kHz (top row) and 120 kHz (bottom row). Example data processing steps include the original echogram (left column), after noise subtraction and bin-averaging (middle column), and after filtering to retain only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

2.3 Trawl sampling

During the day, CPS form schools, typically in the upper mixed layer (e.g., from the surface 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*, the net, a Nordic 264 rope trawl (NET Systems; Bainbridge Island, WA; **Figs. 8a, 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 nearshore one night and 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. 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 (up to 75 for Pacific Sardine and Northern Anchovy and up to 50 for Pacific Mackerel, Jack Mackerel, 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, Pacific Round Herring, and Pacific Herring. In addition, sex and maturity were visually determined and recorded for up to 75 specimens from Pacific Sardine and Northern Anchovy and up to 25 for Pacific and Jack Mackerels. Ovaries were preserved of each CPS, except Pacific Herring, for subsequent histological processing to validate maturity. 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), enabling an evaluation of accuracy for personnel who assessed maturity. Fin clips were removed from 50 Pacific Sardine and 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 in the subsample; for other CPS species (except 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.

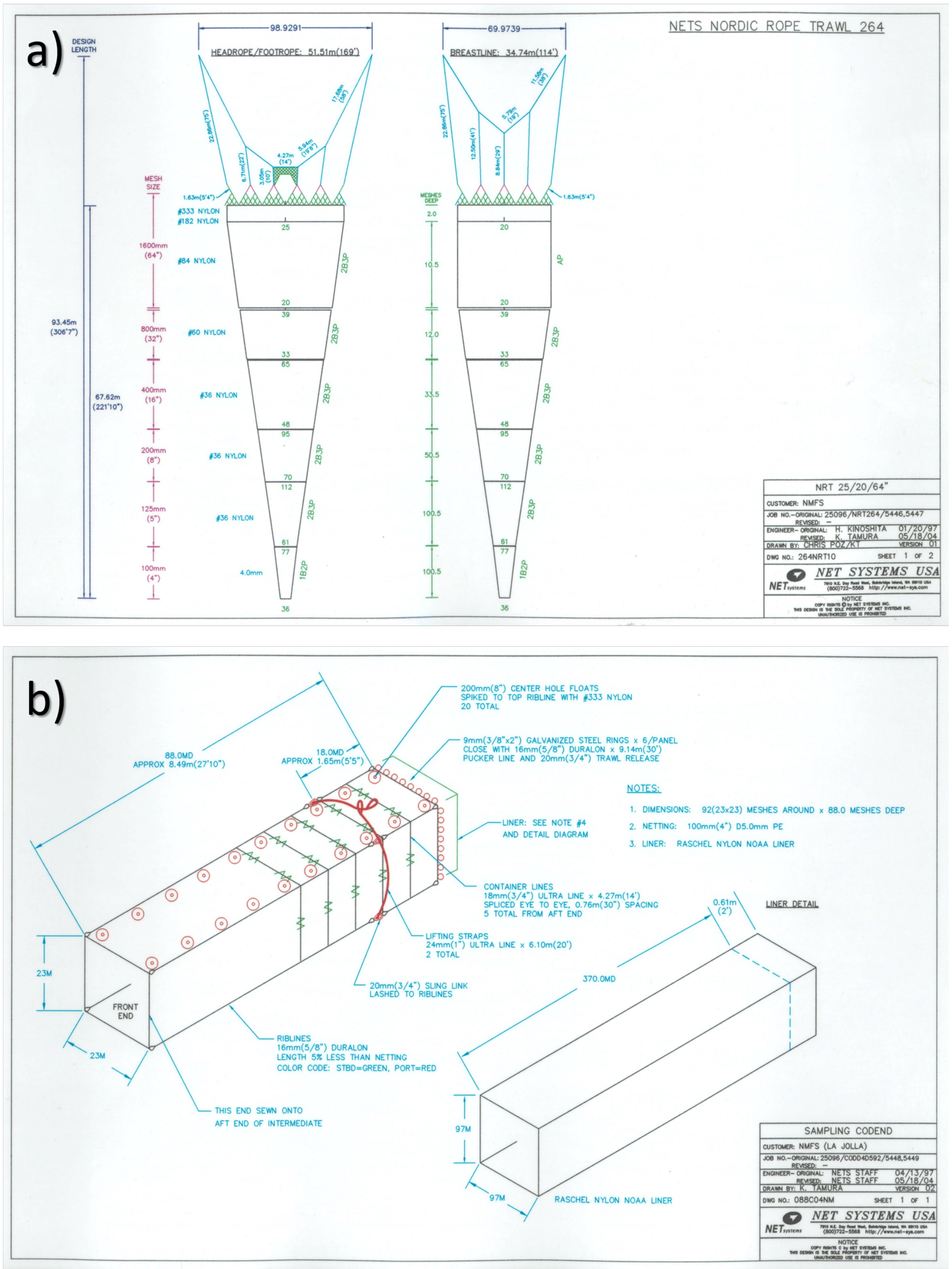

Figure 8: Schematic drawings of the Nordic 264 rope trawl net (a) and cod-end (b) on *Lasker*.

On *Carranza*, up to three trawls were conducted each night. The net, a midwater Mesh Wing Trawl 25/25 (252MWT04i; NET Systems; **Figs. 9**), has equal top and bottom footrope lengths of 48.17 m. The mesh size decreases from 1600 to 50 mm, and is constructed of multifilament nylon cloth and ultra-high molecular weight polyethylene (Vallarta-Zárate *et al.*, 2022). The cod-end is a 17-mm Raschel nylon cloth netting. Trawls were towed at 3.5 to 4 knots for 45 minutes. A sample volume of approximately 15 kg was obtained from each haul. When the biological sample of the target species was less than this volume, the entire sample was processed. Subsequently, the CPS were identified and processed, first by measuring the standard length of each individual in the sample. Then, a proportion of each size interval was obtained with respect to the total number of organisms analyzed, to obtain a subsample for biological sampling that reflects the size distribution observed in the overall sample. The subsample was then processed to obtain specimen length, weight, sex, sexual maturity, fat content, stomach content, and gonadal weight. Otoliths were extracted for future age analysis.

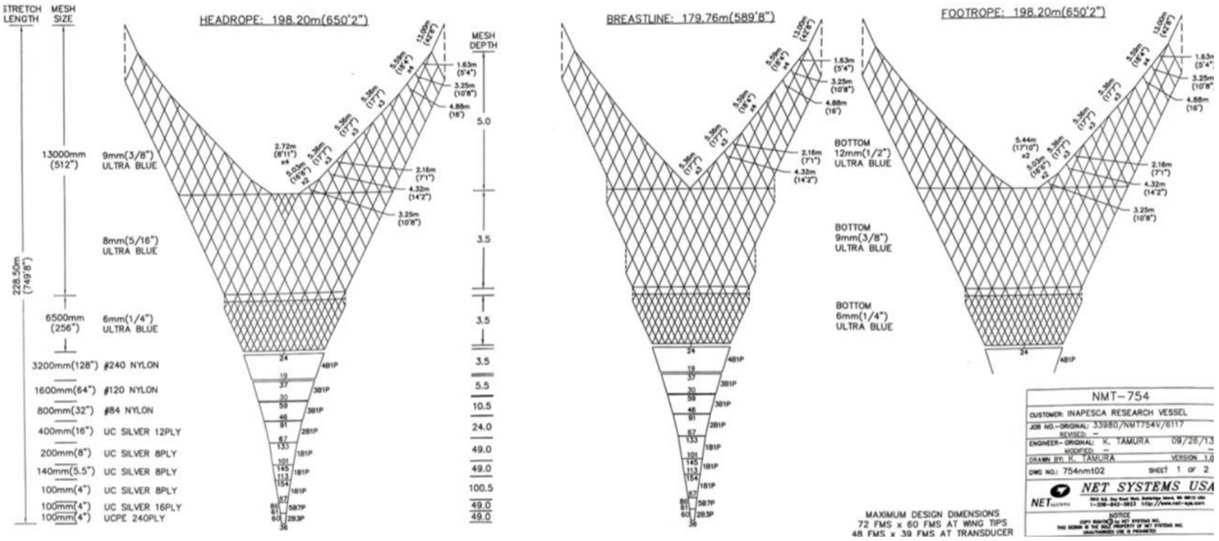

Figure 9: Schematic drawings of the Mesh Wing trawl net on *Carranza*.

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 that sampled the nearshore region. *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.

On *Lisa Marie*, as many as three purse seine sets were planned each day. 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 CPS species were randomly sampled to provide a combined weight for each set. The length (mm; L_S for Pacific Sardine and Northern Anchovy and L_F for all others) and weight was measured for up to 50 randomly selected specimens of each species. Otoliths were extracted, macroscopic maturity stage was determined visually, and gonads were collected and preserved from female specimens.

On *Long Beach Carnage*, as many as three purse seine sets were planned each day, including evenings. 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. 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* and *Carranza*, 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. For each vessel, the particles in the sampled water were sieved by a 505- and 500-μm mesh, respectively. 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 for *Lasker*, and 4 nmi at a speed of 8 kn for *Carranza*. Because the durations of the initial egg stages is short for most CPS, the egg distributions inferred from CUFES samples 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°. Bongo samples were stored in 5% buffered formalin.

2.5.2 Conductivity and temperature versus depth (CTD) sampling

On *Lasker* and *Carranza*, conductivity and temperature were measured versus depth to 350 and 500 m, respectively, using calibrated sensors on a probe cast from the vessel while on station (CTD), or a probe cast from the vessel while underway (UnderwayCTD, or UCTD; Teledyne Oceanscience). These data indicate the depth of the surface mixed layer, above which most epipelagic CPS reside during the day, which is later used to determine the integration-stop depth during acoustic data processing. For *Lasker*, 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). For *Carranza*, the conductivity and temperature from the echosounder calibrations were used for the Echoview processing.

3 Results

3.1 Echosounder calibrations

For *Lasker*, the EK80s were calibrated on 17 June while the vessel was alongside the pier near 10th Avenue Marine Terminal, San Diego Bay (32.6956 °N, -117.15278 °W). Measurements of sea-surface temperature (t_w = 21.1 °C) and salinity (s_w = 34 psu) were measured to a depth of 10 m using a handheld probe (Pro2030, YSI) and input to the WBT-control software (EK80 v2.0.0, Simrad), which derived estimates of sound speed (c_w = 1523.5 m s^{-1}) and absorption coefficients (see **Table 1**). The centerboard was placed in the Retracted position, which resulted in the seabed being approximately 7.6 to 8.1 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: Simrad EK80 wideband transceiver (WBT; 18, 38, 70, 120, 200, and 333 kHz) and transducer information aboard *Lasker*; pre-calibration settings (above horizontal line); and beam model results following calibration (below horizontal line). Prior to the survey, on-axis gain (G_0), beam angles (α_{-3dB} and β_{-3dB}) and angle offsets (α_0 and β_0), and S_a Correction ($S_\mathrm{a}$corr) values from calibration results were entered into the control software (EK80 v2.0.0, Simrad).

		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
On-axis Gain (G_0)	dB re 1	23.1	26.34	27.63	26.79	27.14	26.59
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	-0.03	0.04	-0.01	-0.04	-0.08	-0.14
Bandwidth (W_f)	Hz						
Sample Interval	m	0.028	0.048	0.048	0.04	0.032	0.024
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-17	-20.7	-20.7	-20.7	-20.7	-20.7
Absorption Coefficient (α_f)	dB km^{-1}	0	0	0	0	0	0
Angle Sensitivity Along. (Λ_α)	Elec.°/Geom.°						
Angle Sensitivity Athw. (Λ_β)	Elec.°/Geom.°						
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	10.42	6.46	6.71	6.6	6.57	6.62
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	10.37	6.4	6.73	6.6	6.57	6.55
Angle Offset Along. (α_0)	deg	0	0	0	0	0	0
Angle Offset Athw. (β_0)	deg	0	0	0	0	0	0
Theoretical TS (TS_theory)	dB re 1 m^2	-42.4	-42.4	-41.65	-39.81	-38.82	-36.8
On-axis Gain (G_0)	dB re 1	23.05	25.75	27.41	26.57	26.51	25.46
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	-0.15	-0.01	-0.16	-0.20	-0.26	-0.15
RMS	dB	0.05	0.08	0.07	0.06	0.13	0.32
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	10.39	6.86	6.68	6.57	6.66	6.35
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	10.39	6.87	6.68	6.57	6.59	6.31
Angle Offset Along. (α_0)	deg	-0.03	0.01	-0.03	0	0	-0.01
Angle Offset Athw. (β_0)	deg	-0.01	-0.06	-0.03	0.01	0	0.08

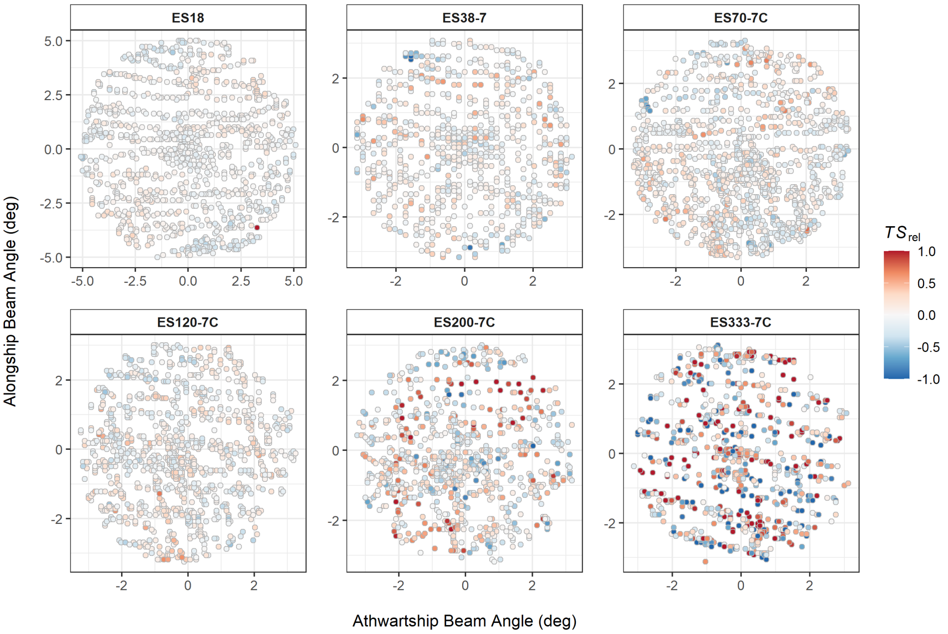

Figure 10: Relative beam-compensated target strength (TS_{rel}, dB re 1 m^2) measurements of a WC38.1 sphere at 18, 38, 70, 120, 200, and 333 kHz for echosounders aboard *Lasker*. TS_{rel} is calculated as the difference between the beam-compensated target strength (TS_c) and the theoretical target strength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

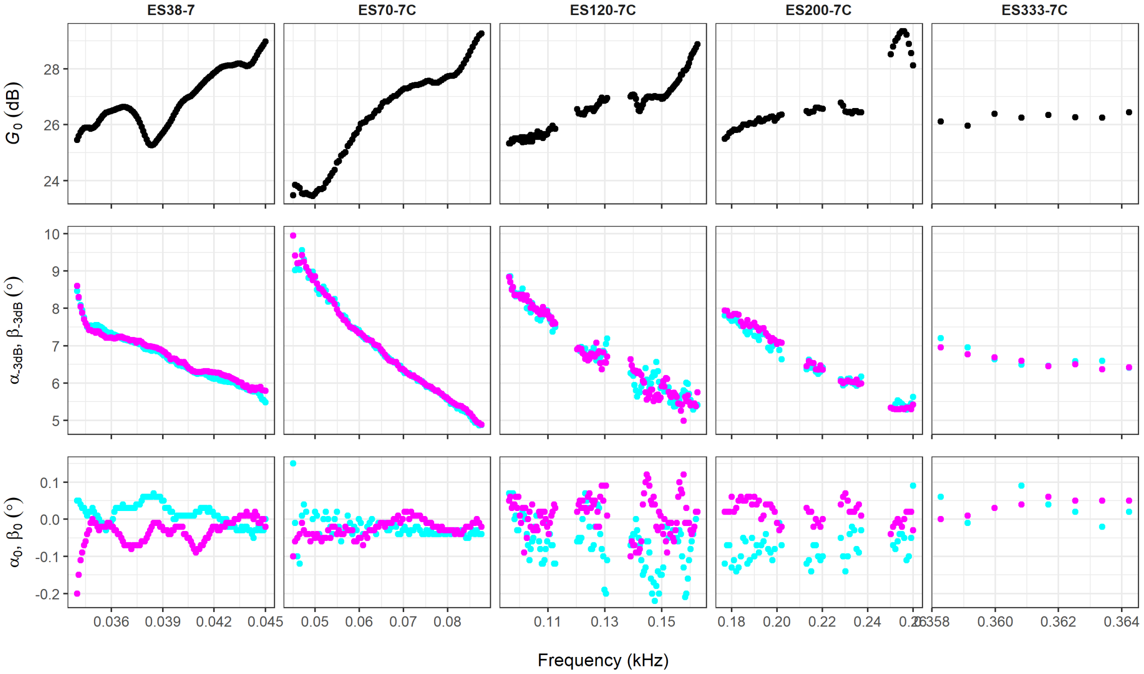

Figure 11: Measurements of on-axis gain (G_0, dB); alongship ($\alpha_{-3\mathrm{dB}}$, cyan) and athwartship ($\beta_{-3\mathrm{dB}}$, magenta) beamwidths (deg); and alongship (α_0, cyan) and athwartship (β_0, magenta) offset angles (deg) measured during calibrations of EK80 wideband transceivers aboard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

For *Carranza*, the 18, 38, and 70-kHz GPTs were calibrated on 29 and 30 January, 2022, using the standard sphere technique. Calibrations were unsuccessful for the 120 and 200-kHz GPTs, and therefore results from the most recent calibration, conducted in September 2020, were used. Beam model results were entered into the EK80 software and are presented in **Table 2**.

Table 2: General Purpose Transceiver (Simrad EK60 GPT) calibrated beam model results estimated from calibrations of the echosounders aboard *Carranza* using either a Cu63 (for 18 kHz) or WC38.1 (for 38, 70, 120, and 200 kHz). Results for the 120 and 200-kHz GPTs are from a calibration conducted in September 2020. Prior to the survey, calibrated on-axis gain (G_0), beam angles and angle offsets, and S_a Correction ($S_\mathrm{a}$corr) values were entered into the GPT-control software (EK80, Simrad).

		Frequency (kHz)				
	Units	18	38	70	120	200
Model		ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Serial Number		1	1	1	1	1
Transmit Power (p_et)	W	2000	2000	750	150	150
Pulse Duration (τ)	ms	1.024	1.024	1.024	0.512	0.512
On-axis Gain (G_0)	dB re 1	22.18	25.5	26.94	26.66	25.84
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	-0.66	0	-0.36	-0.33	-0.14
Bandwidth (W_f)	Hz					
Sample Interval	m	0.256	0.256	0.256	0.128	0.128
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-17	-20.7	-20.7	-20.7	-20.7
Absorption Coefficient (α_f)	dB km^{-1}	1.928	7.415	21.559	46.345	76.155
Angle Sensitivity Along. (Λ_α)	Elec.°/Geom.°					
Angle Sensitivity Athw. (Λ_β)	Elec.°/Geom.°					
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	10.32	6.85	6.69	7.01	7.07
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	10.77	6.92	6.83	6.94	7.12
Angle Offset Along. (α_0)	deg	-0.16	-0.01	0	-0.09	0.06
Angle Offset Athw. (β_0)	deg	-0.03	-0.03	-0.07	0.07	0.04
Theoretical TS (TS_theory)	dB re 1 m^2	-34.64	-42.43	-41.44	-39.47	-39.22
On-axis Gain (G_0)	dB re 1	20.1	23.19	24.69	25.85	25.65
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	0.02	-0.47	-0.08	-0.34	-0.24
RMS	dB	0.27	0.13	0.21	0.23	0.29
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	10.91	7.14	6.98	6.82	6.93
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	11.27	7.54	7.42	6.98	7.24
Angle Offset Along. (α_0)	deg	-0.18	-0.04	0.08	0.16	-0.06
Angle Offset Athw. (β_0)	deg	0.12	0.04	-0.1	-0.11	-0.25

For *Lisa Marie*, the 38-kHz GPT was calibrated on 5 June, 2021 using the standard sphere technique with a WC38.1 while the vessel was anchored in Yaquina Bay near Newport, OR (44.6249, -124.0370). Calibration results for *Lisa Marie* are presented in **Table 3**.

Table 3: General Purpose Transceiver (Simrad EK60 GPT) beam model results estimated from an in situ calibration of echosounders aboard *Lisa Marie* using a WC38.1. Prior to the survey, calibrated on-axis gain (G_0), beam angles and angle offsets, and S_a Correction ($S_\mathrm{a}$corr) values were entered into the GPT-control software (EK80, Simrad).

		Frequency (kHz)
	Units	38
Model		ES38B
Serial Number		0
Transmit Power (p_et)	W	2000
Pulse Duration (τ)	ms	1.024
On-axis Gain (G_0)	dB re 1	25.5
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	0
Bandwidth (W_f)	Hz	
Sample Interval	m	0.256
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-20.7
Absorption Coefficient (α_f)	dB km^{-1}	0
Angle Sensitivity Along. (Λ_α)	Elec.°/Geom.°	
Angle Sensitivity Athw. (Λ_β)	Elec.°/Geom.°	
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	7
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	7
Angle Offset Along. (α_0)	deg	0
Angle Offset Athw. (β_0)	deg	0
Theoretical TS (TS_theory)	dB re 1 m^2	-42.39
On-axis Gain (G_0)	dB re 1	22.13
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	-0.50
RMS	dB	0.07
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	6.74
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	6.72
Angle Offset Along. (α_0)	deg	-0.03
Angle Offset Athw. (β_0)	deg	-0.01

For *Long Beach Carnage*, the echosounders were calibrated using the standard sphere technique with a WC38.1 on 13 October, 2021 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) beam model results estimated from a tank calibration of echosounders aboard *Long Beach Carnage* using a WC38.1. Prior to the survey, calibrated on-axis gain (G_0), beam angles and angle offsets, and S_a Correction ($S_\mathrm{a}$corr) values were entered into the GPT-control software (EK80, Simrad).

		Frequency (kHz)			
	Units	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
On-axis Gain (G_0)	dB re 1	21.5	27	27	26
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	0	0	0	0
Bandwidth (W_f)	Hz				
Sample Interval	m	0.256	0.256	0.256	0.256
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-15.5	-20.7	-20.7	-20.7
Absorption Coefficient (α_f)	dB km^{-1}	0	0	0	0
Angle Sensitivity Along. (Λ_α)	Elec.°/Geom.°				
Angle Sensitivity Athw. (Λ_β)	Elec.°/Geom.°				
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	12.5	7	7	7
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	12.5	7	7	7
Angle Offset Along. (α_0)	deg	0	0	0	0
Angle Offset Athw. (β_0)	deg	0	0	0	0
Theoretical TS (TS_theory)	dB re 1 m^2	-42.38	-41.66	-39.89	-38.82
On-axis Gain (G_0)	dB re 1	21.64	26.38	26.09	26.7
S_a Correction ($S_\mathrm{a}$corr)	dB re 1	-0.70	-0.29	-0.44	-0.25
RMS	dB	0.07	0.04	0.09	0.07
3-dB Beamwidth Along. ($\alpha_{-3\mathrm{dB}}$)	deg	12.55	6.83	6.88	6.78
3-dB Beamwidth Athw. ($\beta_{-3\mathrm{dB}}$)	deg	12.62	6.76	6.81	6.79
Angle Offset Along. (α_0)	deg	-0.02	0.04	0.15	-0.04
Angle Offset Athw. (β_0)	deg	0.07	-0.01	0.03	0

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 (Renfree *et al.*, 2019), and are presented in **Table 5**.

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

		Saildrone (Frequency)					
	Units	1036 (38)	1036 (200)	1055 (38)	1055 (200)	1059 (38)	1059 (200)
Echosounder SN		268641-07	268641-08	266972-07	266972-08	268632-07	268632-08
Transducer SN		110	110	127	127	131	131
Eq. Two-way Beam Angle (Ψ)	dB re 1 sr	-13.0	-11.8	-12.7	-11.7	-12.9	-12.0
Theoretical TS (TS_{theory})	dB re 1 m^2	-42.39	-38.83	-42.40	-38.85	-42.40	-38.85
On-axis Gain (G_0)	dB re 1	19.06	18.52	19.30	18.92	18.99	18.96
S_{a} Correction (S_{a}corr)	dB re 1	0.01	0.04	-0.04	0.11	-0.02	0.05
RMS	dB	0.12	0.33	0.21	0.52	0.21	0.47
3-dB Beamwidth Along. ($\alpha_{-3\text{dB}}$)	deg	17.0	19.1	17.7	19.3	17.5	20.0
3-dB Beamwidth Athw. ($\beta_{-3\text{dB}}$)	deg	17.1	19.9	17.6	20.2	16.8	18.3
Angle Offset Along. (α_0)	deg	0.3	0.0	0.2	0.4	0.1	0.6
Angle Offset Athw. (β_0)	deg	-0.2	-0.1	0.1	-0.2	-0.5	0.20

3.2 Data collection

3.2.1 Acoustic and net sampling

The core survey region spanned an area from approximately Cape Flattery, WA to Punta Abreojos, MX (**Fig. 12**). *Lasker*, *Carranza*, and the three USVs sampled 141 east-west transects totaling 6,773 nmi, and conducted 174 Nordic trawls.

The nearshore region spanned an area from approximately Cape Flattery, WA to San Diego, CA, including around Santa Cruz and Santa Catalina Islands. *Lisa Marie* surveyed from approximately Cape Flattery, WA to Stewarts Point, CA, with 121 east-west transects totaling 556 nmi and 30 purse seine sets (**Fig. 14**). *Long Beach Carnage* surveyed from approximately Stewarts Point to San Diego, CA, and around the Santa Cruz and Santa Catalina Islands, with 133 east-west transects totaling 475 nmi and 28 purse seine sets (**Fig. 15**).

Leg I

On 6 July, *Lasker* departed from 10th Avenue Marine Terminal in San Diego, CA at ~1700 (all times UTC). Prior to the transit toward northern Vancouver Island, the Simrad EC150-3C was calibrated northwest of the sea buoy outside San Diego Bay (32.6598 N, 117.3833 W). Throughout the transit, sampling was conducted during the day with CUFES, EK80s, ME70, MS70 and SX90. Due to departure delays and weather delays during transit, sampling off Vancouver Island was abandoned. On 12 July at ~1930, *Lasker* began acoustic sampling along Transect 140 off Cape Flattery, WA. On 18 July, after sampling most of Transect 116, *Lasker* transited south to Transect 108 and resumed sampling transects from south to north for the remainder of Leg I. On 22 July, acoustic sampling ceased after the completion of Transect 116 off Newport, OR. *Lasker* arrived at the Marine Operations-Pacific (MOC-P) Pier in Newport, OR at ~1730 to complete Leg I.

During Leg I, *Lisa Marie* sampled Transects 352 to 291, the nearshore region between Cape Flattery, WA to Coos Bay, OR, from 16 to 22 July. Two USVs (SD-1055 and SD-1059) sampled Transects 139 to 127, between Cape Flattery, WA to the Columbia River, from 11 to 26 July.

Leg II

On 27 July, after a two-day delay, *Lasker* departed from the Marine Operations-Pacific (MOC-P) Pier at ~1130 and transited south; acoustic sampling resumed along Transect 106 at ~1300 on 28 July. An Autonomous Spar Buoy Recorder (DASBR) was deployed for the SWFSC Marine Mammal and Turtle Division on 31 July before starting Transect 099. After completing Transect 099, *Lasker* transited to Humboldt Bay to embark the Second Cook. On 13 August, acoustic sampling ceased after the completion of Transect 057 off Point Estero in Harmony Headlands State Park. On 15 August, *Lasker* arrived at the 10th Avenue Marine Terminal in San Diego Bay at ~1700 to complete Leg II.

During Leg II, *Lisa Marie* sampled Transects 289 to 231, the nearshore region between Coos Bay, OR to Fort Ross, CA, from 28 July to 5 August. *Long Beach Carnage* sampled Transects 230 to 176, the nearshore region between Fort Ross to Point Conception, CA, from 12 to 21 August. Two USVs (SD-1055 and SD-1059) sampled Transects 125 to 109, between the Columbia River to Coos Bay, OR, from 26 July to 10 August; two USVs (SD-1036 and SD-1055) then sampled Transects 080 to 062, between Point Arena to Big Sur, CA, from 26 August to 6 September.

Leg III

On 8 September, *Lasker* departed from the fuel pier at the 10th Avenue Marine Terminal in San Diego, CA at ~1315 and began the transit to resume acoustic sampling along Transect 053 at ~1500. On 20 September, acoustic sampling ceased after the completion of Transect 039 off San Diego, CA. On 20 September, *Lasker* arrived at the 10th Avenue Marine Terminal at ~0300 to complete Leg III.

During Leg III, *Long Beach Carnage* sampled Transects 174 to 138, the nearshore region between Point Conception, CA to the USA/Mexico border, and the Santa Cruz and Santa Catalina Islands, from 12 to 19 September. Three USVs (SD-1036, SD-1055, and SD-1059) sampled Transects 060 to 040, between Big

Sur to San Diego, CA, from 6 to 24 September, where Transects 051 to 040 were the offshore extents of the *Lasker* transects.

Leg IV

On 25 September, *Lasker* departed from the 10th Avenue Marine Terminal in San Diego Bay at ~1730. Without a permit to begin the survey in Mexico, *Lasker* transited north toward Cape Blanco, OR to conduct additional acoustic sampling along transects where CPS eggs and backscatter were observed toward the offshore ends of previously sampled transects. On 28 September, *Lasker* sought shelter from rough seas in Drake's Bay near San Francisco, CA. Prior to dropping anchor, a second calibration of the EC150-3C ADCP was conducted north of the shipping channel (37.8880 N, 122.8870 W). During this time, engineers tended to the thrust bearing on the propeller shaft that began leaking lubricant during the calibration. At ~1500 on 30 September, *Lasker* weighed anchor and continued the transit to Cape Blanco, OR. At ~1400 on 2 October, acoustic sampling resumed along Transect 107. On 4 October, after sampling a portion of Transect 113, permission to survey in Mexico was received; *Lasker* promptly ceased acoustic sampling and turned south toward Mexico. On 7 October, Keighley Lane was put ashore via the *Lasker* work boat and *Lasker* continued toward the survey area off northern Baja California. At ~1500 on 8 October, acoustic sampling resumed along Transect 031 near Tijuana. On 14 October, acoustic sampling ceased after the completion of transect 018 off Las Flores, MX. On 15 October, *Lasker* arrived at the fuel pier at 10th Avenue Marine Terminal in San Diego at ~0630 to complete the survey.

During Leg IV, *Carranza* sampled Transects 055 to 027, between Las Flores to Punta Abreojos, MX, from 19 October to 8 November.

3.2.2 Ichthyoplankton and oceanographic sampling

A total of 43 CTD casts and 205 UCTD casts were conducted from *Lasker* and *Carranza* (**Fig. 12** and **Appendix B**), and 1,658 CUFES samples were collected underway.

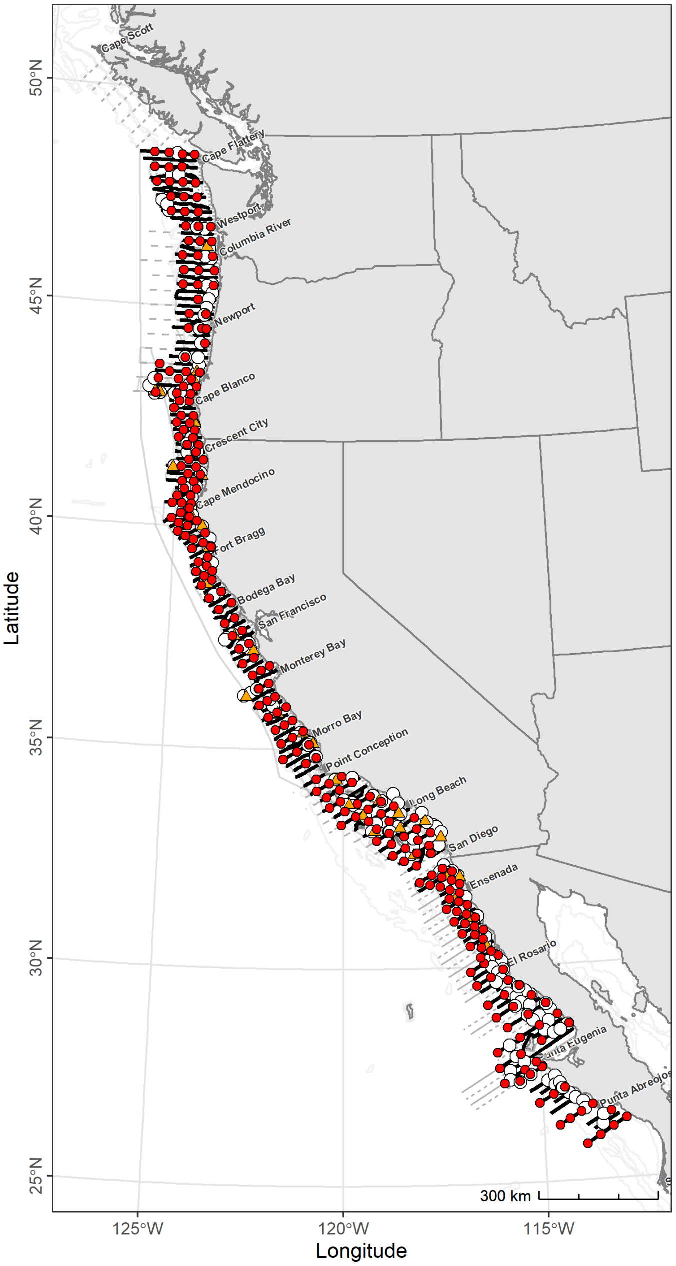

Figure 12: The locations of surface trawls (white points), CTD and UCTD casts (red circles), and bongo nets (orange triangles) relative to the planned east-west acoustic transects (solid and dashed grey lines) and cruise tracks (thick black line) of *Lasker* (north of El Rosario, MX) and *Carranza* (south of El Rosario, MX).

3.3 Distribution of CPS

3.3.1 Core region

Acoustic backscatter ascribed to CPS (**Fig. 13a**), sampled by *Lasker*, *Carranza*, and the USVs, was observed throughout the survey area, but was most prevalent: nearshore between Cape Flattery, WA to Newport, OR, Cape Blanco, OR to Cape Mendocino, CA, and in Baja California; offshore in the Southern California Bight; and dispersed both nearshore and offshore off the coast of California between Cape Mendocino and Point Conception.

Pacific Sardine eggs were abundant in CUFES samples offshore of the Columbia River; offshore between Newport and Cape Blanco, OR; between Tijuana and El Rosario, MX; and off Maria, MX (**Fig. 13b**). Northern Anchovy eggs were most abundant in the Southern California Bight and off San Antonio, MX; and to a lesser extent off of Newport, OR, between Fort Bragg and Bodega Bay, CA, and outside Monterey Bay, CA. Jack Mackerel eggs were observed offshore between Westport, WA and the mouth of the Columbia River; between Newport, OR and Cape Mendocino, CA; and between San Francisco and Monterey Bay, CA. Jack Mackerel eggs were coincident with Pacific Sardine eggs north of Cape Mendocino, CA.

Pacific Sardine were caught in trawls predominantly: between Newport and Cape Blanco, OR; in the Southern California Bight; and between Punta Colonet and Punta Abreojos, MX (**Fig. 13c**). Northern Anchovy were collected throughout the entire survey area south of Oregon. Jack Mackerel were most abundant throughout the survey area between Westport, WA and Cape Mendocino, CA; and in the Southern Califonia Bight down to Punta Abreojos, MX. Pacific Mackerel were caught predominantly between Rosario and Punta Abreojos, MX. Pacific Herring were most abundant off the mouth of the Columbia River and near the border of Oregon and California. Round Herring were only observed north of Punta Eugenia and near Punta Abreojos, MX. The combined catches of the 174 trawls included 17,418 kg of CPS (3,216 kg Pacific Sardine, 11,679 kg Northern Anchovy, 2,009 kg Jack Mackerel, 196 kg Pacific Mackerel, 253 kg Pacific Herring, and 65 kg Round Herring; **Appendix C**).

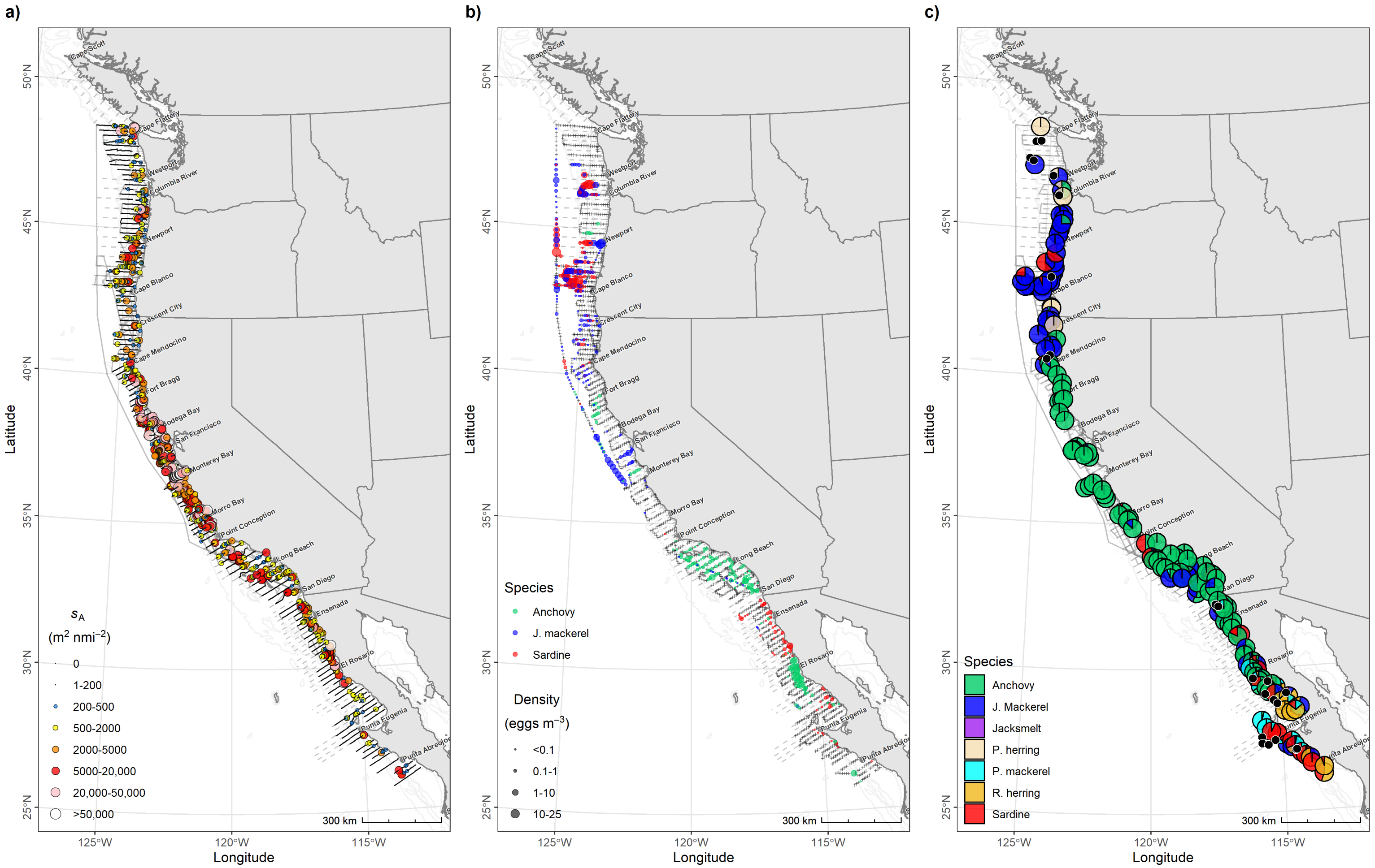

Figure 13: Survey transects overlaid with the distributions of: 38-kHz integrated backscattering coefficients (s_A, m^2 nmi^{-2}; averaged over 2000-m distance intervals and from 5- to 70-m deep) ascribed to CPS (a); egg densities (eggs m^{-3}) for Northern Anchovy, Jack Mackerel, and Pacific Sardine 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 *Lisa Marie* and ascribed to CPS was observed throughout the nearshore survey area, but was most prevalent between the OR/CA border and Bodega Bay, CA (**Fig. 14a**). The CPS backscatter sampled by *Long Beach Carnage* was observed throughout the entire nearshore survey area off California, and was most prevalent between Bodega Bay to San Francisco, San Simeon to Point Conception, Santa Barbara to Ventura, and around Santa Cruz Island (**Fig. 15a**).

Purse seine catches by *Lisa Marie* included predominantly Pacific Herring north of Cape Mendocino, CA, and Northern Anchovy south of Cape Mendocino, CA (**Fig. 14b**). Catches by *Long Beach Carnage* included predominantly Northern Anchovy north of Long Beach, CA; Pacific Sardine south of San Simeon, CA; and Pacific Mackerel near Santa Cruz Island (**Fig. 15b**).

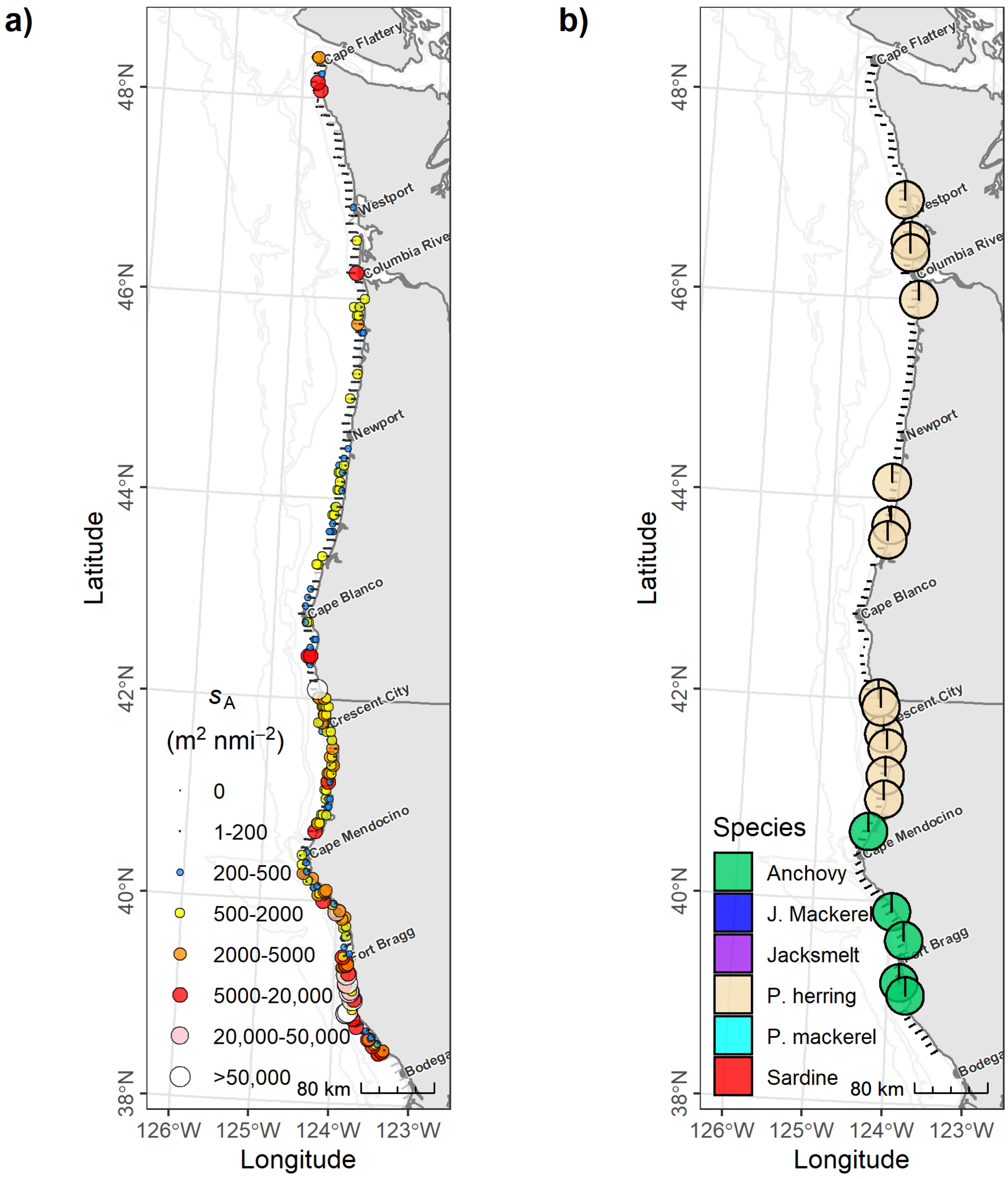

Figure 14: Nearshore survey transects conducted by *Lisa Marie* overlaid with the distributions of: 38-kHz integrated backscattering coefficients (s_A, m^2 nmi^{-2}; averaged over 2000-m distance intervals and from 5- to 70-m deep) ascribed to CPS (a); and the proportions, by weight, of CPS in each purse seine catch (b). Species with low catch weights are not visible at this scale.

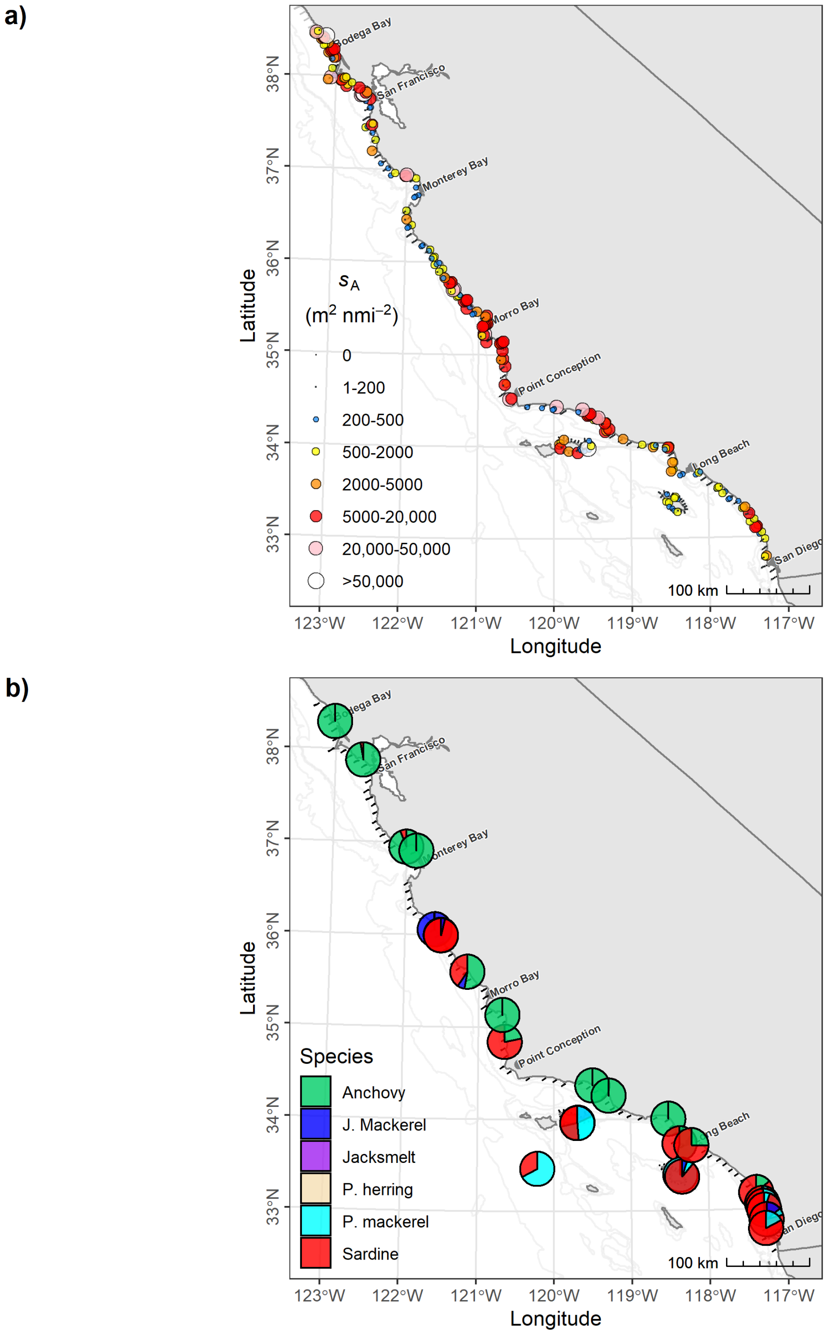

Figure 15: Nearshore survey transects conducted by *Long Beach Carnage* overlaid with the distributions of: 38-kHz integrated backscattering coefficients (s_A, m^2 nmi^{-2}; averaged over 2000-m distance intervals and from 5- to 70-m deep) ascribed to CPS (a); and the proportions, by weight, of CPS in each purse seine catch (b). Species with low catch weights are not visible at this scale.

4 Discussion

The principal objectives of the 86-day Summer 2021 CCE Survey were to survey the northern stock of Pacific Sardine and the northern and central stocks of Northern Anchovy. Then, as possible, to survey the stocks of Pacific Mackerel, Jack Mackerel, Pacific Herring, Pacific Round Herring, and the southern stock of Pacific Sardine. For the first time, the domain of the CCE survey extended coverage into Mexico. The combined sampling from *Lasker*, *Lisa Marie*, *Long Beach Carnage*, Saildrones and *Carranza*, spanned the offshore and nearshore areas from Cape Flattery, WA to Punta Abreojos, MX. The forage fish assemblage was dominated by Jack Mackerel between Westport, WA and Cape Mendocino, CA; Northern Anchovy between Cape Mendocino and El Rosario, MX; and Pacific Sardine between Punta Eugenia, MX and Punta Abreojos, MX. Sardine were virtually absent from catches between Cape Blanco, OR and Monterey Bay, CA, a distance of over 700 km.

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: David Demer (Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, California, 92037, U.S.A.; phone: 858-546-5603; email: david.demer@noaa.gov).

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References

Checkley, D. M., Ortner, P. B., Settle, L. R., and Cummings, S. R. 1997. A continuous, underway fish egg sampler. Fisheries Oceanography, 6: 58–73.

De Robertis, A., and Higginbottom, I. 2007. A post-processing technique to estimate the signal-to-noise ratio and remove echosounder background noise. ICES Journal of Marine Science, 64: 1282–1291.

Demer, D. A. 2004. An estimate of error for the CCAMLR 2000 survey estimate of krill biomass. Deep-Sea Research Part II-Topical Studies in Oceanography, 51: 1237–1251.

Demer, D. A., Berger, L., Bernasconi, M., Bethke, E., Boswell, K., Chu, D., Domokos, R., *et al.* 2015. Calibration of acoustic instruments. ICES Cooperative Research Report No. 326: 133 pp.

Demer, D. A., Cutter, G. R., Renfree, J. S., and Butler, J. L. 2009. A statistical-spectral method for echo classification. ICES Journal of Marine Science, 66: 1081–1090.

Demer, D. A., Zwolinski, J. P., Byers, K. A., Cutter, G. R., Renfree, J. S., Sessions, T. S., and Macewicz, B. J. 2012. Prediction and confirmation of seasonal migration of Pacific sardine (*Sardinops sagax*) in the California Current Ecosystem. Fishery Bulletin, 110: 52–70.

Dorval, E., Schwartzkopf, B. D., James, K. C., Vasquez, L., and Erisman, B. E. 2022. Sampling methodology for estimating life history parameters of coastal pelagic species along the U.S. Pacific Coast. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SWFSC-660: 46 pp.

Dotson, R. C., Griffith, D. A., King, D. L., and Emmett, R. L. 2010. Evaluation of a marine mammal excluder device (MMED) for a Nordic 264 midwater rope trawl. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-SWFSC-455: 19.

Foote, K. G., Knudsen, H. P., Vestnes, G., MacLennan, D. N., and Simmonds. E., J. 1987. Calibration of acoustic instruments for fish density estimation: A practical guide. ICES Cooperative Research Report, 144: 69 pp.

Kim, H. J., Miller, A. J., Neilson, D. J., and McGowan, J. A. 2005. Decadal variations of Mixed Layer Depth and biological response in the southern California current. Sixth Conference on Coastal Atmospheric and Oceanic Prediction and Processes. San Diego.

Mais, K. F. 1974. Pelagic fish surveys in the California Current. State of California, Resources Agency, Dept. of Fish and Game, Sacramento, CA: 79 pp.

Polovina, J. J., Howell, E., Kobayashi, D. R., and Seki, M. P. 2001. The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography, 49: 469–483.

Renfree, J. S., and Demer, D. A. 2016. Optimising transmit interval and logging range while avoiding aliased seabed echoes. ICES Journal of Marine Science, 73: 1955–1964.

Renfree, J. S., Sessions, T. S., Murfin, D. W., Palance, D., and Demer, D. A. 2019. Calibrations of Wide-Bandwidth Transceivers (WBT Mini) with Dual-frequency Transducers (ES38-18/200-18C) for Saildrone Surveys of the California Current Ecosystem During Summer 2018. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SWFSC-608: 29 pp.

Schwartzkopf, B. D., Dorval, E., James, K. C., Walker, J. M., Snodgrass, O. E., Porzio, D. L., and Erisman, B. E. 2022. A summary report on the life history information on the central subpopulation of Northern Anchovy *(Engraulis mordax)* for the 2021 stock assessment. U.S. Dep. Commer., NOAA Tech. Memo., NMFS-SWFSC-659: 76 pp.

Simmonds, E. J., and MacLennan, D. N. 2005. Fisheries Acoustics: Theory and Practice, 2nd Edition. Blackwell Publishing, Oxford.

Smith, P. E., and Richardson, S. L. 1977. Standard techniques for pelagic fish egg and larva surveys. FAO Fisheries Technical Paper No. 175: 108 pp.

Vallarta-Zárate, J. R. F., Huidobro-Campos, L., Martínez-Magaña, V. H., Jacob-Cervantes, M. L., Vásquez-Ortiz, M., Altamirano-López, L., Pérez-Flores, E. V., *et al.* 2022. Evaluación de recursos pesqueros en el Golfo de California durante la primavera del 2021. Campaña Océano Pacífico 2021, B/I Dr. Jorge Carranza Fraser. Instituto Nacional de Pesca y Acuacultura, Dirección de Investigación Pesquera en el Atlántico, 13: 116.

Zwolinski, J. P., Demer, D. A., Byers, K. A., Cutter, G. R., Renfree, J. S., Sessions, T. S., and Macewicz, B. J. 2012. Distributions and abundances of Pacific sardine (*Sardinops sagax*) and other pelagic fishes in the California Current Ecosystem during spring 2006, 2008, and 2010, estimated from acoustic-trawl surveys. Fishery Bulletin, 110: 110–122.

Zwolinski, J. P., Emmett, R. L., and Demer, D. A. 2011. Predicting habitat to optimize sampling of Pacific sardine (*Sardinops sagax*). ICES Journal of Marine Science, 68: 867–879.

Zwolinski, J. P., Oliveira, P. B., Quintino, V., and Stratoudakis, Y. 2010. Sardine potential habitat and environmental forcing off western Portugal. ICES Journal of Marine Science, 67: 1553–1564.

Appendix

A Centerboard positions

Date, time, and location associated with changes to the position of the centerboard and transducer depth. The information is obtained from event data generated by the ship's bridge, and may not be comprehensive.

Date Time	Position (depth)	Latitude	Longitude
07/22/2021 16:57	Retracted (5 m)	44.5697	-124.1443
07/28/2021 00:20	Intermediate (7 m)	44.5385	-124.1510
08/15/2021 13:03	Intermediate (7 m)	32.6137	-117.2455
09/25/2021 18:54	Intermediate (7 m)	32.6240	-117.2627
09/28/2021 00:36	Retracted (5 m)	37.9770	-122.9430
09/30/2021 15:06	Intermediate (7 m)	38.0212	-123.5788

B CTD and UCTD sampling locations

Times and locations of conductivity and temperature versus depth casts while on station (CTD) and underway (UCTD).

Date Time	Cast Type	Latitude	Longitude
07/12/2021 21:30	UCTD	48.4980	-126.3032
07/12/2021 23:38	UCTD	48.5038	-125.8187
07/13/2021 01:27	UCTD	48.4838	-125.3648
07/13/2021 03:07	UCTD	48.4835	-124.9682
07/13/2021 18:40	UCTD	48.1890	-125.3563
07/13/2021 20:33	UCTD	48.1665	-125.7977
07/13/2021 22:32	UCTD	48.1622	-126.2645
07/14/2021 02:05	UCTD	47.8277	-126.1670
07/14/2021 04:03	UCTD	47.8303	-125.7463
07/14/2021 14:09	UCTD	47.8348	-125.3112
07/14/2021 16:05	UCTD	47.8370	-124.8877
07/14/2021 22:19	UCTD	47.5028	-124.8255
07/15/2021 00:05	UCTD	47.4987	-125.2412
07/15/2021 01:55	UCTD	47.4953	-125.6755
07/15/2021 14:58	UCTD	47.1612	-125.6372
07/15/2021 16:56	UCTD	47.1648	-125.1982
07/15/2021 18:59	UCTD	47.1672	-124.7565
07/16/2021 00:10	UCTD	46.8363	-124.3153
07/16/2021 01:49	UCTD	46.8332	-124.7275
07/16/2021 03:28	UCTD	46.8313	-125.1395
07/16/2021 13:37	UCTD	46.5033	-124.2663
07/16/2021 15:25	UCTD	46.5003	-124.6495
07/16/2021 16:54	UCTD	46.4972	-125.0150
07/16/2021 20:51	UCTD	46.1618	-125.1810
07/16/2021 23:02	UCTD	46.1637	-124.6952
07/17/2021 01:16	UCTD	46.1680	-124.2160
07/17/2021 14:59	UCTD	45.8335	-124.1377
07/17/2021 17:17	UCTD	45.8305	-124.6378
07/17/2021 19:19	UCTD	45.8273	-125.1155
07/17/2021 22:53	UCTD	45.4943	-125.1215
07/18/2021 01:07	UCTD	45.4972	-124.6465
07/18/2021 03:31	UCTD	45.5003	-124.1437
07/18/2021 15:48	UCTD	45.1632	-124.6235
07/18/2021 22:52	UCTD	44.8302	-124.8745
07/19/2021 01:41	UCTD	44.8320	-124.3497
07/19/2021 16:46	UCTD	44.4985	-124.4488
07/19/2021 18:50	UCTD	44.4978	-124.8782
07/20/2021 13:21	UCTD	43.1693	-124.5328
07/20/2021 15:21	UCTD	43.1677	-124.9350
07/20/2021 23:02	UCTD	43.4963	-125.3860
07/21/2021 01:15	UCTD	43.5002	-124.8770
07/21/2021 03:02	UCTD	43.5015	-124.4555
07/21/2021 16:56	UCTD	43.8318	-124.9335
07/22/2021 00:26	UCTD	44.1673	-124.3365

(continued)

Date Time	Cast Type	Latitude	Longitude
07/22/2021 14:49	UCTD	44.4987	-124.3173
07/28/2021 15:47	UCTD	42.8365	-125.0408
07/28/2021 17:13	UCTD	42.8372	-124.7313
07/28/2021 20:09	UCTD	43.0032	-124.7002
07/28/2021 22:03	UCTD	43.0013	-125.1355
07/29/2021 15:00	UCTD	42.6685	-125.1982
07/29/2021 19:46	UCTD	42.5060	-124.5883
07/29/2021 21:26	UCTD	42.5045	-124.9583
07/30/2021 00:43	UCTD	42.3402	-125.0857
07/30/2021 02:33	UCTD	42.3402	-124.6843
07/30/2021 13:49	UCTD	42.1755	-124.5285
07/30/2021 15:20	UCTD	42.1743	-124.8640
07/30/2021 18:43	UCTD	42.0072	-125.0098
07/30/2021 20:47	UCTD	42.0085	-124.5763
07/31/2021 00:32	UCTD	41.8445	-124.3887
07/31/2021 02:11	UCTD	41.8430	-124.7432
07/31/2021 17:14	UCTD	41.6787	-124.4595
08/01/2021 17:45	UCTD	41.5125	-124.6643
08/01/2021 19:35	UCTD	41.5130	-124.2342
08/01/2021 22:23	UCTD	41.3470	-124.4388
08/02/2021 00:17	UCTD	41.3463	-124.8760
08/02/2021 16:25	UCTD	41.1823	-124.2847
08/02/2021 18:10	UCTD	41.1810	-124.6650
08/03/2021 00:06	UCTD	41.0147	-124.8368
08/03/2021 01:54	UCTD	41.0147	-124.4810
08/03/2021 14:43	UCTD	40.8508	-124.3865
08/03/2021 16:30	UCTD	40.8498	-124.7547
08/03/2021 19:32	UCTD	40.6848	-124.9550
08/03/2021 21:25	UCTD	40.6848	-124.5602
08/04/2021 00:56	UCTD	40.5198	-124.5300
08/04/2021 02:14	UCTD	40.5205	-124.8067
08/04/2021 14:50	UCTD	40.5188	-125.0850
08/04/2021 20:39	UCTD	40.1697	-125.0885
08/04/2021 22:03	UCTD	40.2915	-124.8208
08/04/2021 23:21	UCTD	40.4028	-124.5755
08/05/2021 02:03	UCTD	40.2123	-124.5685
08/05/2021 14:22	UCTD	40.0688	-124.8798
08/05/2021 17:31	UCTD	39.8675	-124.8927
08/05/2021 19:09	UCTD	40.0008	-124.6013
08/05/2021 20:31	UCTD	40.1223	-124.3333
08/06/2021 00:52	UCTD	39.7818	-124.6580
08/06/2021 13:59	UCTD	39.8562	-124.0817
08/06/2021 15:45	UCTD	39.7047	-124.4087
08/06/2021 18:54	UCTD	39.4927	-124.4373
08/06/2021 20:35	UCTD	39.6370	-124.1248
08/06/2021 23:30	UCTD	39.5480	-123.8892
08/07/2021 14:38	UCTD	39.3197	-123.9657

(continued)

Date Time	Cast Type	Latitude	Longitude
08/07/2021 16:13	UCTD	39.1923	-124.2408
08/07/2021 19:25	UCTD	38.9772	-124.2868
08/07/2021 21:03	UCTD	39.1150	-123.9880
08/07/2021 23:44	UCTD	39.0008	-123.8213
08/08/2021 01:01	UCTD	38.8887	-124.0572
08/08/2021 16:47	UCTD	38.8038	-123.8282
08/08/2021 18:26	UCTD	38.6692	-124.1125
08/08/2021 22:09	UCTD	38.3825	-123.8867
08/09/2021 00:05	UCTD	38.5488	-123.5392
08/09/2021 15:29	UCTD	38.1367	-123.5828
08/09/2021 17:29	UCTD	38.3003	-123.2365
08/09/2021 21:15	UCTD	37.9532	-123.1267
08/09/2021 22:42	UCTD	37.8300	-123.3990
08/10/2021 02:45	UCTD	37.5507	-123.1685
08/10/2021 15:23	UCTD	37.6827	-122.8923
08/10/2021 19:42	UCTD	37.3857	-122.6988
08/10/2021 21:10	UCTD	37.2557	-122.9682
08/11/2021 01:16	UCTD	36.9240	-122.8487
08/11/2021 02:55	UCTD	37.0690	-122.5430
08/11/2021 17:16	UCTD	36.8918	-122.0957
08/11/2021 18:28	UCTD	36.7838	-122.3250
08/11/2021 20:02	UCTD	36.6707	-122.5602
08/11/2021 23:14	UCTD	36.3667	-122.3890
08/12/2021 13:43	UCTD	36.3688	-122.3787
08/12/2021 15:10	UCTD	36.4988	-122.1077
08/12/2021 18:38	UCTD	36.1982	-121.9245
08/12/2021 19:42	UCTD	36.0993	-122.1302
08/12/2021 20:55	UCTD	35.9903	-122.3563
08/13/2021 00:40	UCTD	35.7270	-122.0942
08/13/2021 01:58	UCTD	35.8420	-121.8557
08/13/2021 14:17	UCTD	35.9625	-121.6065
08/13/2021 17:19	UCTD	35.6625	-121.4200
08/13/2021 18:29	UCTD	35.5575	-121.6392
08/13/2021 19:50	UCTD	35.4378	-121.8875
08/13/2021 22:34	UCTD	35.1312	-121.7180
08/14/2021 00:12	UCTD	35.2770	-121.4178
08/14/2021 01:48	UCTD	35.4205	-121.1217
09/09/2021 15:15	UCTD	34.8263	-120.7475
09/09/2021 16:55	UCTD	34.6863	-121.0330
09/09/2021 20:59	UCTD	34.7692	-121.6603
09/09/2021 23:11	UCTD	34.9527	-121.2843
09/10/2021 01:06	UCTD	35.1177	-120.9458
09/10/2021 16:39	UCTD	34.3315	-120.7470
09/10/2021 21:05	UCTD	34.0610	-120.7360
09/10/2021 23:06	UCTD	34.2313	-120.3900
09/11/2021 01:07	UCTD	34.4025	-120.0425
09/11/2021 16:47	UCTD	34.2608	-119.7663
09/11/2021 18:46	UCTD	34.0912	-120.1118

(continued)

Date Time	Cast Type	Latitude	Longitude
09/11/2021 20:59	UCTD	33.9207	-120.4580
09/12/2021 00:17	UCTD	33.6827	-120.3790
09/12/2021 02:01	UCTD	33.8300	-120.0802
09/12/2021 21:18	UCTD	33.9498	-119.2788
09/12/2021 23:40	UCTD	33.8228	-118.9762
09/13/2021 15:19	UCTD	33.6515	-119.3220
09/13/2021 17:17	UCTD	33.4817	-119.6642
09/13/2021 19:32	UCTD	33.2900	-120.0517
09/13/2021 22:45	UCTD	33.6088	-119.9665
09/14/2021 00:45	UCTD	33.7798	-119.6213
09/14/2021 15:19	UCTD	33.5453	-118.9790
09/14/2021 17:17	UCTD	33.7158	-118.6363
09/15/2021 00:37	UCTD	33.4425	-118.0780
09/15/2021 17:24	UCTD	33.3757	-118.7535
09/16/2021 01:05	UCTD	33.0207	-118.3683
09/16/2021 13:58	UCTD	33.3740	-119.3233
09/16/2021 20:28	UCTD	33.2025	-119.1012
09/16/2021 23:17	UCTD	33.1007	-118.7628
09/17/2021 01:14	UCTD	32.9290	-119.1055
09/17/2021 15:13	UCTD	32.8507	-118.7108
09/17/2021 19:22	UCTD	32.5885	-118.6778
09/17/2021 21:24	UCTD	32.7593	-118.3377
09/18/2021 00:33	UCTD	32.4627	-118.3783
09/18/2021 14:47	UCTD	33.1928	-118.0243
09/18/2021 21:36	UCTD	33.1007	-117.6572
09/19/2021 14:26	UCTD	32.9302	-117.9990
09/19/2021 17:57	UCTD	32.6398	-118.0293
09/19/2021 19:56	UCTD	32.8098	-117.6903
09/20/2021 15:12	UCTD	32.6283	-117.6568
09/20/2021 18:15	UCTD	32.3563	-118.0455
10/02/2021 15:03	UCTD	43.0020	-124.7013
10/02/2021 16:59	UCTD	43.0003	-125.1372
10/02/2021 21:20	UCTD	43.3292	-125.0977
10/02/2021 23:04	UCTD	43.3333	-124.7088
10/03/2021 15:58	UCTD	42.9973	-125.7780
10/03/2021 22:59	UCTD	43.3240	-125.7240
10/04/2021 17:28	UCTD	43.6567	-125.7172
10/08/2021 15:45	UCTD	32.2788	-117.3538
10/08/2021 17:31	UCTD	32.1327	-117.6462
10/08/2021 19:27	UCTD	31.9650	-117.9748
10/08/2021 23:23	UCTD	31.9102	-117.7007
10/09/2021 01:06	UCTD	32.0697	-117.3847
10/09/2021 14:59	UCTD	32.2090	-117.1070
10/09/2021 20:13	UCTD	32.0092	-117.1167
10/09/2021 21:55	UCTD	31.8573	-117.4210
10/10/2021 00:57	UCTD	31.7833	-117.1808
10/10/2021 14:41	UCTD	31.9187	-116.9142

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Date Time	Cast Type	Latitude	Longitude
10/10/2021 16:53	UCTD	31.7182	-116.9238
10/10/2021 18:21	UCTD	31.5807	-117.1970
10/10/2021 20:40	UCTD	31.3505	-117.2698
10/10/2021 22:28	UCTD	31.5112	-116.9483
10/11/2021 14:15	UCTD	31.4292	-116.7302
10/11/2021 15:48	UCTD	31.2922	-116.9997
10/11/2021 18:42	UCTD	31.0522	-117.0877
10/11/2021 20:36	UCTD	31.2215	-116.7542
10/12/2021 15:01	UCTD	31.1440	-116.5270
10/12/2021 16:39	UCTD	31.0027	-116.8042
10/12/2021 19:25	UCTD	30.7673	-116.8827
10/12/2021 21:19	UCTD	30.9335	-116.5553
10/12/2021 23:52	UCTD	30.8555	-116.3280
10/13/2021 01:15	UCTD	30.7397	-116.5552
10/13/2021 16:55	UCTD	30.4783	-116.6870
10/13/2021 18:57	UCTD	30.6475	-116.3533
10/14/2021 00:34	UCTD	30.4348	-116.3913
10/14/2021 15:00	UCTD	30.3602	-116.1550
10/14/2021 16:38	UCTD	30.2188	-116.4300
10/18/2021 11:04	CTD	29.6763	-115.7376
10/18/2021 17:01	CTD	29.9301	-115.8581
10/18/2021 20:08	CTD	30.2566	-115.9702
10/19/2021 10:11	CTD	30.0790	-116.3409
10/19/2021 13:59	CTD	29.8815	-116.6992
10/20/2021 12:57	CTD	29.7515	-116.1826
10/20/2021 16:41	CTD	29.5710	-116.5488
10/21/2021 16:43	CTD	29.3463	-115.8483
10/23/2021 10:53	CTD	29.5539	-115.4578
10/23/2021 19:43	CTD	29.3182	-115.1527
10/24/2021 11:08	CTD	29.1273	-116.2832
10/25/2021 06:27	CTD	29.0622	-115.6280
10/25/2021 11:01	CTD	28.8223	-116.0872
10/25/2021 14:35	CTD	28.5871	-115.8109
10/25/2021 19:36	CTD	28.8726	-115.2672
10/26/2021 10:20	CTD	29.1171	-114.7985
10/26/2021 13:29	CTD	28.8641	-114.5195
10/26/2021 20:19	CTD	28.6252	-114.2378
10/28/2021 08:48	CTD	28.6188	-114.9904
10/28/2021 13:08	CTD	28.3471	-115.4956
10/28/2021 18:24	CTD	28.0283	-116.0827
10/29/2021 05:51	CTD	27.6596	-116.0496
10/29/2021 10:59	CTD	27.9721	-115.5001
10/30/2021 12:51	CTD	28.2596	-114.9529
10/31/2021 14:47	CTD	27.3061	-115.9337
11/01/2021 05:40	CTD	27.6829	-114.9772
11/01/2021 19:02	CTD	27.6574	-114.9815
11/01/2021 21:02	CTD	27.7733	-115.1198
11/02/2021 04:00	CTD	27.6067	-115.4108

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Date Time	Cast Type	Latitude	Longitude
11/02/2021 12:48	CTD	27.4960	-115.2790
11/02/2021 16:02	CTD	27.3487	-115.5490
11/03/2021 14:22	CTD	27.1609	-114.4276
11/04/2021 13:39	CTD	26.8233	-115.0785
11/04/2021 20:04	CTD	27.0097	-114.7199
11/06/2021 04:53	CTD	26.7419	-113.7585
11/06/2021 07:29	CTD	26.5866	-114.0515
11/06/2021 10:45	CTD	26.4304	-114.3452
11/06/2021 13:51	CTD	26.2938	-114.6014
11/07/2021 06:39	CTD	26.5656	-113.3070
11/08/2021 16:23	CTD	26.3891	-112.9418
11/08/2021 19:24	CTD	26.2103	-113.2739
11/08/2021 22:38	CTD	26.0201	-113.6175
11/09/2021 01:59	CTD	25.8365	-113.9491

C Trawl sample summary

Date, time, 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.

Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
2	07/13/2021 10:20	48.4903	-125.4943			246.09				246.09
3	07/14/2021 05:46	47.9580	-125.6670							
4	07/14/2021 09:15	47.9897	-125.4210							
5	07/15/2021 05:41	47.4112	-125.9763							
6	07/15/2021 07:47	47.3210	-125.7993							
7	07/15/2021 10:28	47.1773	-125.7275	0.96						0.96
8	07/16/2021 06:51	46.8352	-124.7990							
9	07/16/2021 09:24	46.7942	-124.5500	3.09		0.95				4.04
10	07/17/2021 05:56	46.3515	-124.3548	2.80	4.20	1.26				8.26
11	07/17/2021 09:22	46.1692	-124.4713							
12	07/17/2021 11:40	46.1220	-124.2940			0.07				0.07
13	07/18/2021 05:52	45.4952	-124.1755	60.21				0.98		61.19
14	07/18/2021 08:23	45.5015	-124.3553	39.74			0.58	0.53		40.85
15	07/18/2021 10:58	45.3445	-124.1812	92.43		0.08				92.51
16	07/19/2021 05:42	45.1542	-124.2643	38.64	12.95					51.59
17	07/19/2021 08:40	45.0098	-124.3348	85.98	8.23					94.21
18	07/19/2021 10:55	44.8388	-124.3918	543.96						543.96
19	07/20/2021 05:22	43.5132	-124.5523	98.60				4.18		102.78
20	07/20/2021 08:03	43.3497	-124.6340	105.70						105.70
21	07/20/2021 10:29	43.1798	-124.6688	11.79						11.79
22	07/21/2021 05:33	43.6388	-124.4707	172.83		1.84		11.77		186.44
23	07/21/2021 08:04	43.8153	-124.5130	84.02		0.69		30.64		115.35
24	07/21/2021 11:24	43.8097	-124.9057	33.16				54.48		87.64
25	07/22/2021 07:51	44.1442	-124.4528	72.12	0.04	0.45		131.53		204.14
26	07/22/2021 11:30	44.4755	-124.5300	127.51						127.51
27	07/28/2021 09:40	43.0075	-125.0415	41.88			0.56			42.44
28	07/29/2021 05:09	43.0183	-125.6392	29.31						29.31
29	07/29/2021 08:58	43.0113	-125.1973	34.30			1.94			36.24
30	07/29/2021 11:37	42.8487	-125.0022	1.98						1.98
31	07/30/2021 05:31	42.3460	-124.5592			0.16				0.16

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Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
32	07/30/2021 09:19	42.2460	-124.5553			1.00				1.00
33	07/31/2021 07:02	41.9830	-124.6067	9.78			0.47			10.25
34	07/31/2021 10:21	41.8212	-124.5367	3.30						3.30
35	08/01/2021 07:41	41.6417	-124.7053	1.71						1.71
36	08/01/2021 11:35	41.8410	-124.7312	10.40						10.40
37	08/02/2021 05:02	41.3308	-125.0842	13.25				0.30		13.55
38	08/02/2021 10:52	41.6787	-124.3977			0.21				0.21
39	08/03/2021 05:28	41.1773	-124.2532		0.02					0.02
40	08/03/2021 08:57	41.0270	-124.5263	31.71				0.77		32.47
41	08/03/2021 11:12	40.9253	-124.4208	6.00						6.00
42	08/04/2021 05:15	40.8473	-124.7323	12.74						12.74
43	08/04/2021 08:35	40.6872	-124.5252							
44	08/04/2021 11:24	40.5085	-124.6468							
45	08/05/2021 05:19	40.3120	-124.7233	1.11				0.17		1.28
46	08/05/2021 08:13	40.4265	-124.5468		1.09	0.04		0.11		1.24
47	08/05/2021 10:24	40.2717	-124.4620	0.01	0.04					0.05
48	08/06/2021 08:23	39.9892	-124.1517		543.50	0.62				544.12
49	08/07/2021 07:12	39.7102	-123.9110		0.79					0.79
50	08/07/2021 10:14	39.5453	-123.9453		1.85					1.85
51	08/08/2021 06:35	39.0933	-124.0117	0.14	52.61					52.75
52	08/08/2021 09:21	39.1300	-123.8922		623.76		0.79			624.55
53	08/08/2021 11:46	39.1670	-123.8217		693.09					693.09
54	08/09/2021 04:59	38.7123	-123.9808		22.62					22.62
55	08/09/2021 09:32	38.4417	-123.7327		1746.93					1746.93
56	08/10/2021 05:28	37.5690	-123.1523		73.87					73.87
57	08/10/2021 08:09	37.4745	-123.2993		1399.13					1399.13
58	08/10/2021 11:12	37.4378	-123.3498		23.88					23.88
59	08/11/2021 05:00	37.2393	-122.6092		103.16					103.16
60	08/11/2021 07:25	37.3845	-122.6718	0.05	1.12					1.17
61	08/11/2021 09:53	37.2998	-122.8353	0.01	63.26					63.27
62	08/12/2021 04:36	36.1777	-122.7652	0.07	1.49					1.56
63	08/12/2021 07:53	36.2510	-122.5712	0.02	44.52			0.06		44.59
64	08/12/2021 10:59	36.3373	-122.4072		1317.48					1317.48

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Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
65	08/13/2021 05:01	35.8320	-121.8683	0.05	498.28					498.33
66	08/13/2021 07:28	35.9622	-121.9523	0.04	25.27					25.30
67	08/13/2021 10:04	36.1133	-122.0432	0.09	339.26					339.35
68	08/14/2021 04:14	35.3872	-121.1703		0.37			0.02		0.39
69	08/14/2021 06:22	35.3143	-121.3510		140.35					140.35
70	09/10/2021 03:00	35.1495	-120.8837		5.14			0.01		5.15
71	09/10/2021 05:40	35.0967	-120.9447	0.09	681.42			0.35		681.87
72	09/10/2021 10:07	34.8237	-120.7322	0.01	0.08					0.09
73	09/11/2021 04:18	34.3172	-120.1917		65.53		0.12	65.57		131.22
74	09/11/2021 09:28	34.3673	-119.7820		3.79		0.02			3.81
75	09/12/2021 04:47	33.8727	-120.0067	5.01	0.16		3.44	125.93		134.55
76	09/12/2021 07:45	33.8222	-119.7765	0.29	79.89		0.14	2.35		82.66
77	09/12/2021 11:08	33.7495	-119.8885		0.58					0.58
78	09/13/2021 03:20	33.9942	-118.6112		2.55					2.55
79	09/13/2021 06:44	33.8322	-118.9328		39.69		0.15	0.04		39.87
80	09/13/2021 10:01	33.9472	-119.1687	0.00	1.21					1.21
81	09/14/2021 05:01	33.7260	-119.6838		60.38			0.02		60.39
82	09/14/2021 08:19	33.5302	-119.5793		44.24		0.09	0.32		44.65
83	09/14/2021 11:11	33.4918	-119.4335	0.05	20.05					20.10
84	09/15/2021 03:27	33.5438	-117.8457	0.09	106.08		0.14	0.13		106.44
85	09/15/2021 07:55	33.5232	-118.4172	1.54	0.49		1.45	0.02		3.50
86	09/15/2021 11:59	33.7683	-118.4790	0.27	249.77			1.12		251.16
87	09/16/2021 04:06	33.2228	-118.5098	0.82	0.11		0.01			0.93
88	09/16/2021 06:51	33.3267	-118.7883	0.03	42.02					42.05
89	09/16/2021 09:53	33.3285	-119.0845		0.25					0.25
90	09/17/2021 05:13	33.1383	-119.2012	2.71	0.85		0.21			3.77
91	09/17/2021 09:20	33.1423	-118.7863	0.41	8.09		0.03			8.54
92	09/17/2021 11:11	33.1315	-118.7138	0.01						0.01
93	09/18/2021 04:58	32.6027	-118.1427	1.62	2.49		0.25			4.36
94	09/18/2021 08:04	32.7823	-118.0863	1.04	1.17		0.01			2.22
95	09/18/2021 11:08	32.9622	-118.0838	0.00	0.08					0.08
96	09/19/2021 03:00	33.2573	-117.5547	19.19	10.34		0.69			30.23
97	09/19/2021 05:50	33.2160	-117.4725	9.43	44.65		35.50	34.36		123.94

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Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
98	09/19/2021 08:27	33.3155	-117.7168	0.07	20.10		0.34			20.51
100	09/20/2021 06:09	33.0877	-117.3478		18.72		0.04	0.06		18.81
102	09/21/2021 03:53	32.6713	-117.6198	1.16	577.04		1.03	2.74		581.97
103	09/21/2021 07:42	32.7995	-117.4462	0.22	0.64					0.87
104	10/03/2021 03:15	43.3082	-124.6210							
105	10/03/2021 06:12	43.2197	-124.7613	1.50						1.50
106	10/03/2021 09:23	43.0572	-125.0262	3.63				0.24		3.87
107	10/04/2021 04:06	42.9957	-125.8060	13.50			1.30			14.80
108	10/04/2021 08:01	43.1607	-125.9832	3.94						3.94
109	10/04/2021 11:15	43.2948	-125.8565	0.76				0.24		1.00
110	10/08/2021 07:08	32.3737	-117.3185		5.13			0.02		5.15
111	10/08/2021 09:25	32.2362	-117.4137							
112	10/08/2021 11:32	32.1677	-117.3253							
113	10/09/2021 03:36	32.0770	-117.0970	0.33	21.21		1.70	0.19		23.42
114	10/09/2021 06:27	31.8323	-117.0225		0.07					0.07
115	10/09/2021 09:23	31.9212	-117.2738	0.03						0.03
116	10/10/2021 04:13	32.0948	-116.9300	1.02	26.78		0.01	0.14		27.95
117	10/10/2021 06:31	32.1917	-117.0790	0.33	50.55		0.34	0.36		51.58
118	10/10/2021 09:30	32.1913	-117.2027	0.04	19.17					19.20
119	10/11/2021 03:21	31.6232	-117.0417		47.97			0.34		48.32
120	10/11/2021 06:23	31.5535	-116.8892	0.03	58.09			0.38		58.49
121	10/11/2021 09:41	31.5913	-116.7448		72.55			0.14		72.69
122	10/12/2021 03:45	31.3815	-116.7703		15.34			0.06		15.40
123	10/13/2021 05:46	31.1542	-116.4427	5.15	0.11		5.99	1293.72		1304.96
124	10/13/2021 09:32	31.0898	-116.5562		0.18			0.04		0.22
125	10/14/2021 04:32	30.4817	-116.2703		0.89					0.89
126	10/14/2021 08:13	30.6723	-116.2598	0.13	0.33					0.46
127	10/14/2021 11:19	30.4712	-116.3555		39.34		0.34	0.43		40.11
128	10/19/2021 04:36	30.0389	-116.0133		67.14		3.93	2.44		73.52
129	10/19/2021 08:26	30.1147	-116.2565	0.47						0.47
130	10/19/2021 10:53	30.2213	-116.0459	11.19	302.63		1.46	9.15		324.43
131	10/20/2021 03:42	30.1032	-115.8984	7.88	0.93		7.71	1.83	2.02	20.37
132	10/20/2021 06:06	29.9478	-115.8605		32.06		8.62	1320.06		1360.74
133	10/20/2021 09:15	29.9794	-116.1090		0.23		0.29			0.52

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Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
134	10/21/2021 05:27	29.8355	-115.9997		33.90		2.48	0.82		37.20
135	10/21/2021 08:20	29.7184	-115.8852	0.32	661.20		3.42	9.68		674.63
136	10/21/2021 10:20	29.6494	-116.0172							
137	10/22/2021 02:45	29.4813	-115.5944	102.10	251.49		34.54	6.70		394.83
138	10/22/2021 06:00	29.6309	-115.6817	13.74	36.64			0.10		50.49
139	10/22/2021 08:03	29.5775	-115.7853	0.15	49.00		12.12	0.63	2.62	64.52
140	10/24/2021 04:20	29.3385	-115.1924	0.08			1.77	2.95	5.42	10.22
141	10/24/2021 07:13	29.4096	-115.2954		0.03					0.03
142	10/24/2021 10:06	29.5296	-115.4983							
143	10/25/2021 05:39	29.3854	-115.7850		35.20		5.14	13.00	0.29	53.63
144	10/25/2021 08:00	29.3041	-115.5454		6.56			0.11		6.67
145	10/25/2021 10:31	29.1048	-115.5817							
146	10/26/2021 05:54	29.1658	-115.4594		13.31		0.06	0.03	0.06	13.46
147	10/26/2021 08:11	29.0975	-115.2329	10.38			6.08	14.92	0.53	31.91
148	10/26/2021 11:05	28.8813	-115.2409							
149	10/27/2021 09:31	29.1141	-114.8018							
150	10/27/2021 12:34	28.8520	-114.9452						0.75	0.75
151	10/28/2021 02:47	28.7292	-115.1664							
152	10/28/2021 06:50	28.9584	-114.7233	0.08				0.08	0.66	0.82
153	10/28/2021 09:56	28.7425	-114.7387				0.16		1.05	1.21
154	10/29/2021 04:22	28.1990	-115.7823		0.45		10.97			11.42
155	10/29/2021 07:19	27.9328	-115.6218				2.17			2.17
156	10/30/2021 05:08	28.5092	-114.8956						0.42	0.42
157	10/30/2021 07:31	28.4371	-114.6612						0.17	0.17
158	10/30/2021 11:05	28.5976	-114.2963	0.38			0.58		0.09	1.05
159	10/31/2021 03:18	28.4979	-114.4285				2.03	2.10	10.38	14.51
160	11/01/2021 03:33	27.6112	-115.7924							
161	11/02/2021 04:19	27.7438	-115.1718					16.00		16.00
162	11/02/2021 07:42	27.7991	-115.4390				0.56	7.87		8.43
163	11/03/2021 01:32	27.4070	-115.7913							
164	11/03/2021 04:34	27.3525	-115.5498							
165	11/03/2021 09:03	27.5056	-115.2789							
166	11/04/2021 05:00	27.3575	-114.8450	12.50			1.46	2.65		16.61

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Haul	Date Time	Latitude	Longitude	J. Mackerel	N. Anchovy	P. Herring	P. Mackerel	P. Sardine	R. Herring	All CPS
167	11/04/2021 07:59	27.4430	-114.6909				1.50	5.17	1.60	8.28
168	11/04/2021 11:19	27.1450	-114.5222							
169	11/05/2021 05:28	27.2513	-114.6656	1.70			0.20	0.07		1.97
170	11/05/2021 08:15	27.3041	-114.5495	2.06			25.74	28.80	37.43	94.02
171	11/05/2021 10:17	27.1562	-114.5046							
172	11/06/2021 03:53	27.0141	-114.3477				4.99	4.15		9.14
173	11/06/2021 06:11	26.9298	-114.1951	0.00				0.04		0.04
174	11/06/2021 08:17	26.8339	-114.0206	0.06					0.13	0.19
175	11/07/2021 04:04	26.6304	-113.9552					1.53		1.53
176	11/08/2021 07:44	26.2972	-113.5228					0.18	0.22	0.40
177	11/08/2021 11:29	26.5157	-113.4964					0.05	0.79	0.83