Supplementary Information

Basin sill depth and episodic flushing influence bathypelagic prey communities and goose-beaked whale foraging in the Southern California Bight

Dolan et al.

Table S1. Deployment summary for all sites. HARP = High-frequency Acoustic Recording Package; WBAT = Wideband Autonomous Transceiver; MicroCAT = SBE37 conductivity, temperature, and (at some deployments) dissolved oxygen sensor. Coordinates are mean deployment position in decimal degrees.

Site	Deployment	Instrument	Start Date	End Date	Days
W	W_02 *33.541, −120.259*	WBAT	2022-03-10	2022-05-27	78
		MicroCAT	2022-03-10	2022-05-25	78
	W_03 *33.541, −120.260*	WBAT	2022-05-27	2022-10-14	139
		MicroCAT	2022-05-27	2022-10-14	139
	W_04 *33.541, −120.260*	WBAT	2022-10-18	2023-04-15	179
		MicroCAT	2022-10-18	2023-04-15	179
	W_05 *33.542, −120.258*	WBAT	2023-04-17	2023-09-25	161
		MicroCAT	2023-04-17	2023-09-25	161
	Site W totals	WBAT			557
		MicroCAT			557
H	H_73 *32.861, −119.136*	WBAT	2021-12-21	2022-05-22	151
		MicroCAT	2021-12-21	2022-05-22	151
	H_74 *32.862, −119.136*	MicroCAT	2022-05-24	2022-10-15	144
	H_75 —	MicroCAT	2022-10-17	2023-04-17	182
	Site H totals	WBAT			151
		MicroCAT			477
E	E_61 *32.660, −119.448*	HARP	2017-03-05	2017-07-10	127
		WBAT	2017-03-05	2017-07-10	127
		MicroCAT	2017-03-05	2017-07-10	127
	E_62 *32.659, −119.480*	HARP	2017-07-13	2018-02-10	212
		WBAT	2017-07-13	2017-11-14	126
		MicroCAT	2017-07-13	2018-03-13	243
	E_63 *32.653, −119.485*	HARP	2018-03-15	2018-07-11	118
		WBAT	2018-03-15	2018-07-11	118
		MicroCAT	2018-03-15	2018-04-30	47
	E_64 *32.658, −119.476*	HARP	2018-07-12	2018-11-28	139
	E_65 *32.656, −119.474*	HARP	2018-11-29	2019-05-07	159

Continued on next page

Table S1 continued

Site	Deployment	Instrument	Start Date	End Date	Days
	E_67 *32.659, −119.480*	HARP	2019-11-09	2020-05-08	181
	E_68 *32.659, −119.480*	HARP	2020-05-09	2020-10-29	173
	E_71 *32.658, −119.485*	HARP	2021-11-20	2022-05-19	180
		WBAT	2021-11-20	2022-05-19	180
		MicroCAT	2021-11-20	2022-05-23	184
	E_72 *32.659, −119.484*	HARP	2022-11-20	2023-05-23	184
		WBAT	2022-05-23	2022-10-11	140
		MicroCAT	2022-05-23	2022-10-11	140
	Site E totals	HARP			1473
		WBAT			691
		MicroCAT			812

Table S2. Summary of conservative temperature (Θ; °C) and absolute salinity (S_A; g kg^{-1}) ranges by site. Δ represents the difference between maximum and minimum values. Counts indicate the number of h observations collected at each site. Sampling effort calculated in number of days is also provided.

Site	Θ Range (°C)	$\Delta\Theta$	S_A Range (g kg^{-1})	ΔS_A	h Obs.	Sampling Days
W	3.33–3.78	0.46	34.665–34.695	0.030	14,225	592.7
E	3.64–3.98	0.35	34.638–34.669	0.031	12,659	527.5
H	3.77–3.99	0.22	34.662–34.680	0.018	11,307	471.1
All Sites	3.33–3.99	0.67	34.638–34.695	0.056	38,191	1,591.3

Table S3. Site-specific GAMs for putative prey backscatter (s_A) and associated model parameters. edf = estimated degrees of freedom.

Site	Predictor	GAM Equation	k	edf	k-index	Dev. Explained (%)
W	σ_0	$s_A \sim s(\sigma_0,\ \texttt{bs="ts"},\ k=6)$	6	4.00	0.95	7.0
E	σ_0	$s_A \sim s(\sigma_0,\ \texttt{bs="ts"},\ k=6)$	6	1.02	0.92	19.0
H	DO	$s_A \sim s(\mathrm{DO},\ \texttt{bs="ts"},\ k=4)$	4	1.01	0.95	4.3

Table S4. Identified flushing events, defined as $\Delta\Theta \leq -0.1$ °C over a 6-h window concurrent with increases in S_A and DO.

Site	Date	$\Delta\Theta$ (°C)	ΔS_A (g kg^{-1})	ΔO_2 (mmol m^{-3})
E	2017-10-01	−0.124	+0.0109	No Data
W	2021-09-19	−0.110	+0.0078	+28.8
W	2022-05-09	−0.105	+0.0077	+27.5
W	2022-09-16	−0.164	+0.0116	+28.5
W	2023-08-27	−0.154	+0.0103	+29.9

Table S5. Manufacturer specifications for MicroCAT environmental sensors. Accuracy and stability/drift are provided for each measured parameter.

Parameter	Reported Accuracy	Stability/Drift
Temperature	±0.002 °C	0.0002 °C per month
Conductivity	±0.0003 S m^{-1}	0.0003 S m^{-1} per month
Oxygen	0.07 mL L^{-1}	< 1 μmol kg^{-1} per 100,000 samples

Table S6. End-member properties used in OMP analysis, derived from the World Ocean Atlas 2023 (WOA23) annual climatology at 33°N, 120°W.

Water Mass	Θ (°C)	S_A (g kg^{-1})	Depth (m)	σ_0 (kg m^{-3})
NPIW	6.78	34.35	375	26.82
AAIW	5.40	34.50	600	27.103
UCDW	2.42	34.77	1650	27.619

Table S7. WBAT deployment metadata including transducer type, transducer serial number (S/N), number of active pings per duty cycle (and active duration), acoustic power, range, gain, and beam geometry. Deployments are grouped by site (E, H, W). Transducer abbreviations: 18CD = ES70-18CD; 7CD = ES70-7CD.

Site	Site E					Site H	Site W			
	E_61	E_62	E_63	E_71	E_72	H_73	W_02	W_03	W_04	W_05
Transducer	18CD	18CD	18CD	18CD	18CD	7CD	7CD	7CD	7CD	7CD
Transducer S/N	211	211	208	204	244	156	115	154	154	156
Duty cycle (pings)	80 (117 s)	80 (117 s)	79 (116 s)	25 (97 s)	25 (97 s)	10 (36 s)	10 (36 s)	10 (36 s)	8 (28 s)	8 (28 s)
Power (W)	250	250	300	300	300	500	500	500	500	500
Range (m)	125	125	125	125	125	300	300	300	300	300
Gain (dB)	19.46	19.46	19.71	19.60	19.61	27.10	26.67	27.16	27.16	27.14
2-Way (°)	−12.6	−12.6	−12.8	−12.7	−12.6	−20.2	−20.6	−20.3	−20.3	−20.2
Major axis (°)	20.13	20.13	17.58	18.56	18.87	7.90	8.39	7.10	7.10	7.28
Minor axis (°)	20.52	20.52	17.31	18.50	18.13	7.32	7.18	7.22	7.22	7.19

Table S8. Summary of the longest continuous periods used for spectral analysis at Sites E, H, and W.

Site	Variables	n Points	Start	End	Duration (h)	Duration (d)
E	σ_0, s_A	2370	2017-07-22 10:36	2017-10-29 13:36	2379	99.1
H	σ_0, s_A	2500	2022-01-01 00:10	2022-04-15 10:10	2506	104.4
W	σ_0, s_A	2993	2022-06-09 19:10	2022-10-12 23:10	3004	125.2

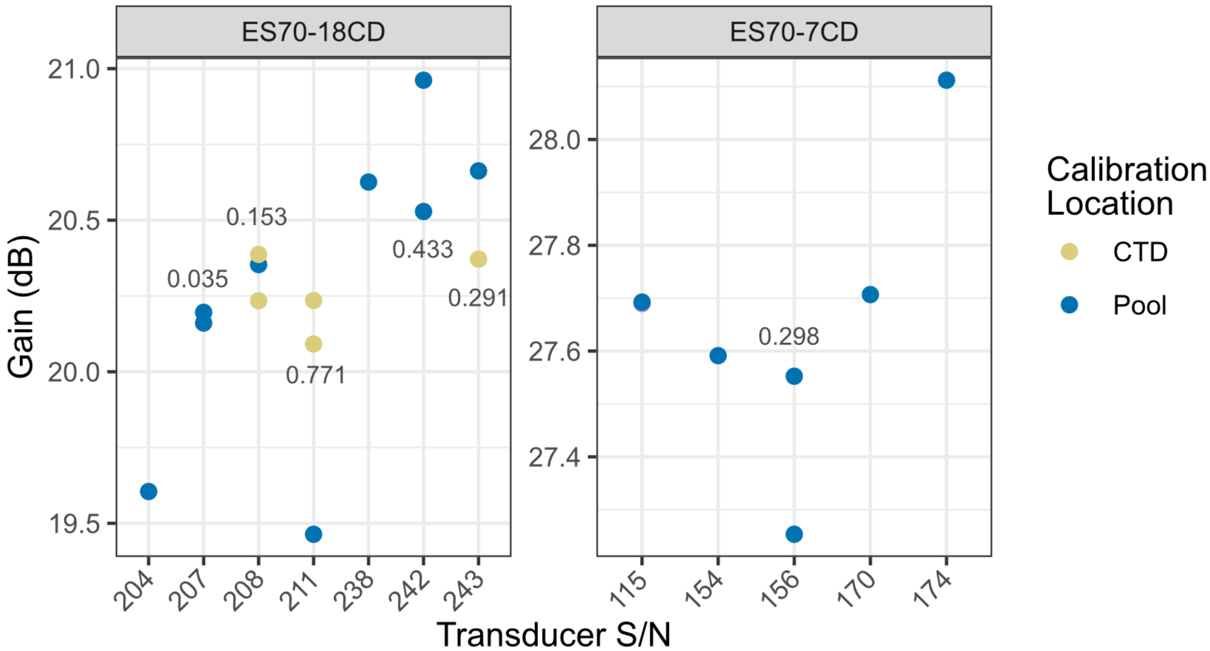

Figure S1. Gain estimates from pool and CTD-based calibrations for ES70-18CD (left) and ES70-7CD (right) transducers, plotted by transducer serial number. Gold points indicate CTD-based calibrations; blue points indicate pool calibrations. Labeled values indicate the absolute difference (dB) between paired CTD and pool estimates for individual transducers. All differences fall within the range of reported calibration uncertainty (± 0.8 dB) for split-beam systems.

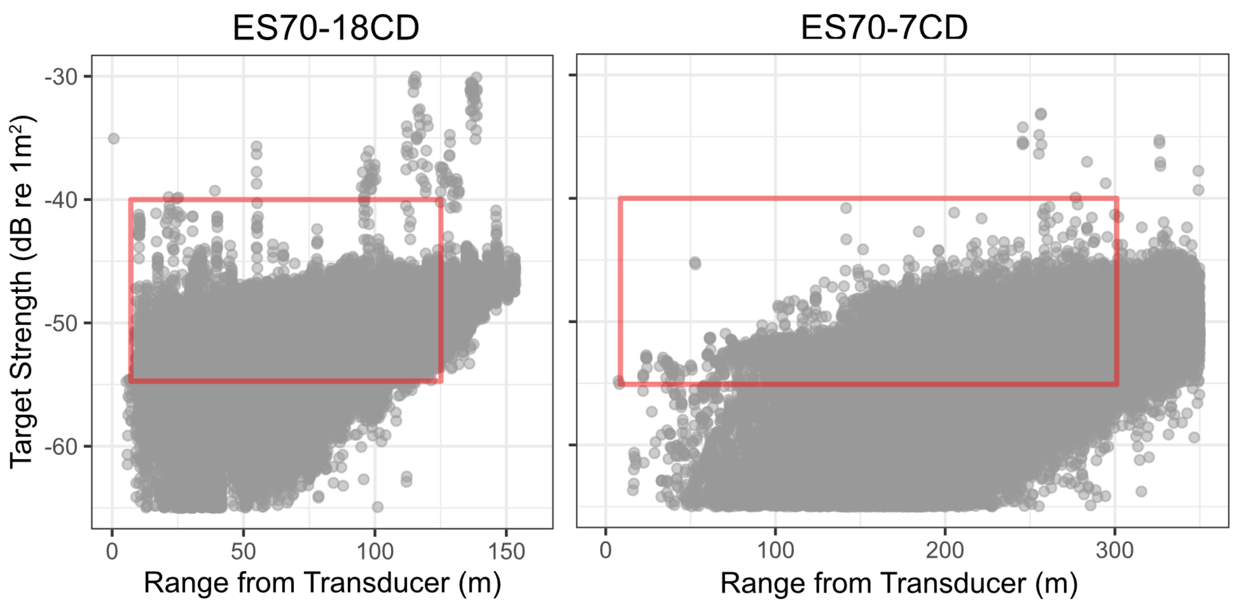

Figure S2. Target strength (TS; dB re 1 m^2) as a function of range from transducer for ES70-18CD (left) and ES70-7CD (right) systems. Each point represents a single target detection from an *in situ* organism. Red rectangles indicate the analysis range windows applied consistently across both s_A and TS analyses: 10–125 m for the ES70-18CD and 10–300 m for the ES70-7CD. Detections outside these windows were excluded from all backscatter analyses.

Supplementary Methods

MicroCAT Note

Observed hydrographic variability substantially exceeded manufacturer-reported sensor precision (Table S5). The total Θ range across sites (0.67 °C) is approximately two orders of magnitude greater than the sensor accuracy (±0.002 °C), and the total S_A range (0.056 g kg^{-1}) substantially exceeds the stated conductivity accuracy when converted to absolute salinity (Table S5). Agreement with available CTD comparisons confirmed that instruments were sufficiently stable and precise to resolve real environmental variability at the scales examined.

A constant S_A offset (0.2 g kg^{-1}) was identified for one Site E deployment (March 2018) relative to adjacent records, exceeding both instrument precision and the range of observed variability at that site. This was interpreted as a sensor calibration offset rather than a physical signal, and was corrected by aligning the mean S_A of the first 24 h at depth with the final 24 h of the preceding deployment; no concurrent Θ change indicated a true hydrographic shift across the intervening three-day gap.

Rare extreme outliers were removed following visual inspection of site-specific distributions. At Site H, h-binned S_A values below 34.66 g kg^{-1} were excluded (20 of 11,327 samples; 0.18%), and at Site E values below 34.63 g kg^{-1} were excluded (17 of 12,676 samples; 0.13%). No S_A outliers were identified at Site W.

Echosounder Calibration Note

Calibration followed standard methods using 38.1 mm tungsten carbide reference spheres in both pool and *in situ* CTD configurations [1, 2]. Between 2017 and 2023, 25 CTD-based calibrations were attempted; current-induced motion of the calibration sphere reduced on-axis detections in several deployments, preventing reliable gain estimation in those cases. The most recent validated pool calibration was applied where CTD-based calibrations were insufficient.

Where sufficient on-axis detections were obtained, CTD-based calibrations produced gain estimates consistent with pool calibrations across variations in depth, temperature, pressure, and sound speed (Figure S1). Reported calibration uncertainty for split-beam systems is typically within ±0.2 dB under controlled conditions [1], with practical variability up to ±0.8 dB [3]. All calibrations in this study fell within this expected ±0.8 dB range, consistent with previous work showing that environmental variability with depth has minimal impact on transducer response and calibration stability [4]. Because this study focuses on relative temporal and spatial patterns rather than absolute biomass estimation, minor differences between CTD and pool calibrations are not expected to affect results.

Transducer ranges used for analysis (125–300 m depending on transducer type; see Table S7) were applied consistently across both s_A and TS analyses (Figure S2). Full calibration procedures and results are reported above in Tables S6 and Figures S1–S2.

References

[1] John Simmonds and David N MacLennan. *Fisheries acoustics: theory and practice*. John Wiley & Sons, 2008.

[2] David A Demer, Laurent Berger, Matteo Bernasconi, Eckhard Bethke, Kevin Boswell, Dezhang Chu, Reka Domokos, Adam Dunford, Sascha Fassler, and Stephane Gauthier. Calibration of acoustic instruments. 2015.

[3] Lars Rudstam and Patrick Sullivan. Acoustics Unpacked: A General Guide for Deriving Abundance Estimates from Hydroacoustic Data.

[4] Kunnath Haris, Rudy J Kloser, Tim E Ryan, and Jacques Malan. Deep-water calibration of echosounders used for biomass surveys and species identification. *ICES Journal of Marine Science*, 75(3):1117–1130, 2018.