signal generally decreases with distance from a transducer. But in the near surface layer, measurements are contaminated by the lobe effect and air bubbles, and the signal becomes stronger. The mean profiles of intensity were calculated and then the averaged cutoff bin was determined. Typically, bins 61–63 (nearest ocean surface) and shallower bin data were unusable; thus, data within about 20 m (18.5–21.5 m) of the ocean surface were omitted from our analyses. In a few cases, erroneous values, likely caused by air bubbles (produced by strong winds and wave breaking) at depths greater than that of the averaged cutoff bin were also omitted and extrapolation was employed.

The relationship between zooplankton biomass and acoustic backscatter intensity was established by comparing biomass obtained from net tows and ensemble ADCP data.

Zooplankton biomass data used for regression with ADCP data were the sum total DW per unit volume filtered for all size fractions of the individual tows taken from September 2, 1996 to November 14, 2000. For each of the concurrent zooplankton sampling time periods, ADCP backscatter intensity data were averaged over the depths of nominally 20 m to the deepest zooplankton sampling depth. This latter depth is typically 200 m, but can vary from 75 to 292 m and thus introduces some error. We performed individual calibrations for data collected during each separate deployment as well as for the ensemble of deployments (Table 2). The relationship between zooplankton biomass and ADCP data was weak or not statistically significant for a few deployments (see r^2 and p values, respectively, in Table 2). Possible reasons for the weaker relationships for some deployments include: locations of zooplankton net tow sampling were too far away from the BTM (i.e., beyond reasonable coherence length scale−spatial patchiness); maximum net tow sampling depths were not always close to the depth range of the ADCP; and relatively fewer tows were taken during some BTM deployments.

Because the slope and intercept for the ensemble (overall) calibration are similar to most of those of the individual deployments (Table 2), we applied the following ensemble calibration formula to all of the data (see Fig. 1 for regression calibration curve)

$$\mathrm{Log}(\mathrm{DW}/4\pi) = 0.0313 * S_v + 2.0631 \quad (r^2 = 0.25,\ p \ll 0.05,\ n = 156), \tag{2}$$

where DW is total DW of zooplankton biomass per unit volume, S_v is the backscattering strength in dB re $(4\pi\,\mathrm{m})^{-1}$. Although the r^2 value for the regression formula is low, the relationship between zooplankton DW and ADCP backscatter intensity is highly significant. Further, the purpose of this study is to examine variability in zooplankton as related to environmental and biological conditions rather than establishing quantitative estimates of zooplankton populations. Future studies will need to be mindful of the need for specially designed calibrations.

2.4. Estimation of vertical velocity using ADCP data

The ADCP measures the speed of scattering particles suspended in water, rather than the water

Table 2
Summary of calibration results

Deployment no.	ADCP time periods	Net tow time periods	Symbols in Fig. 1	$\mathrm{Log}(\mathrm{DW}/4\pi) = A^*S_v + B$				
				r^2	p	A	B	n
6	08/21/96–01/10/97	09/02/96–12/14/96	Dot	0.6504	0.000161	0.0363	2.4945	16
7	05/03/97–07/30/97	05/05/97–07/15/97	Circle	0.3823	0.032108	0.0282	1.9632	12
8	08/08/97–11/20/97	08/11/97–01/14/97	Plus	0.6007	0.000421	0.0330	2.1306	16
9	11/26/97–03/31/98	12/09/97–03/25/98	x-mark	0.0803	0.179610	0.0198	1.1963	24
10	11/11/98–03/19/99	11/18/98–02/24/99	Square	0.5536	0.000031	0.0688	5.0825	24
11	04/01/99–07/21/99	04/07/99–07/06/99	Star	0.1753	0.066156	0.0233	1.4958	20
12	07/29/99–11/06/99	08/03/99–10/12/99	Diamond	0.6923	0.002805	0.0317	2.0181	10
13	12/05/99–05/27/00	12/08/99–04/11/00	Triangle	0.1856	0.213930	0.0252	1.5714	10
14	06/01/00–11/29/00	06/06/00–11/14/00	Pentagram	0.6576	0.0000015	0.0358	2.4257	24
Overall				0.2454	4.9029e−011	0.0313	2.0631	156

Correlation coefficient (r^2) and significance level (p) are given for the regression (see Methods for explanation of variables in regression equation); n is number of samples used in the regression.